SOME EFFECTS OF

Ionizing Radiation

ON HUMAN BEINGS

A Report on the Marshallese and Americans Accidentally Exposed to Radiation from Fallout and a Discussion of Radiation Injury in the Human Being

from the
Naval Medical Research Institute
Bethesda 14, Maryland
U. S. Naval Radiological Defense Laboratory
San Francisco, California
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UNITED STATES
ATOMIC ENERGY COMMISSION
JULY 1956

Report TID-5358

PLATE 1.—*Early hyperpigmented maculopapular neck lesions at 15 days. Case 39, age 15, F.*

PLATE 2.—*Neck lesions at 28 days. Wet desquamation. White color is calamine lotion. Case 78, age 37, F.*

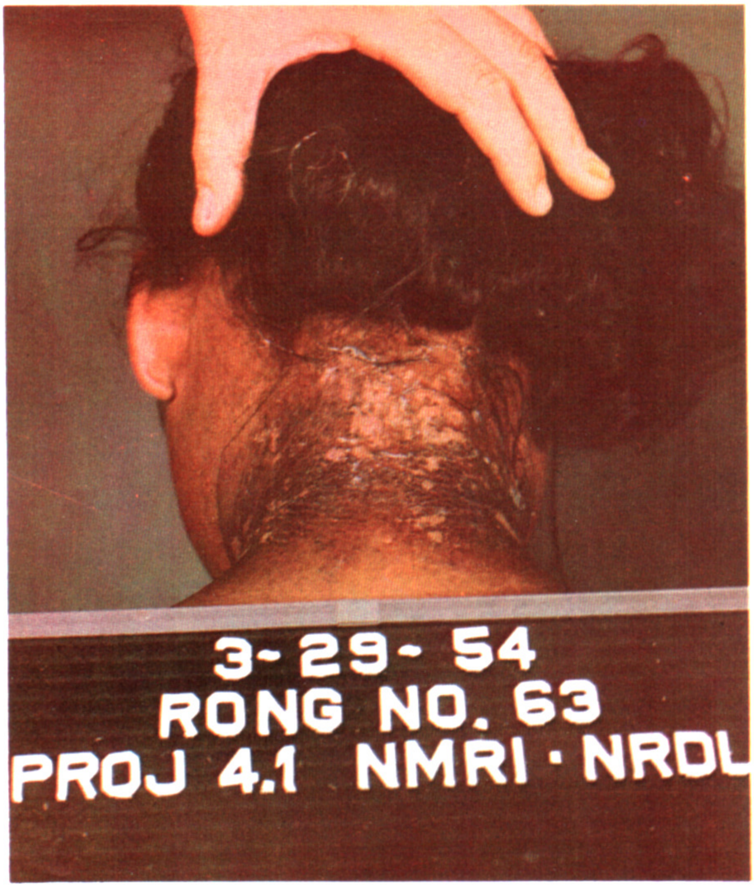

PLATE 3.—*Neck lesions 28 days post-exposure. Note pigmented and desquamated, depigmented areas. Case 63, age 38, F.*

PLATE 4.—*Same case as in Plate 3, six months after exposure. Neck has healed completely.*

Plate 5.—*Hyperpigmented raised plaques and bullae on dorsum of feet and toes at 28 days. One lesion on left foot shows deeper involvement. Feet were painful at this time.*

Plate 6.—*Lesions 10 days later. Bullae have broken, desquamation is essentially complete, and lesions have healed. Feet no longer painful.*

Plate 7.—*Lesions 6 days later showing repigmentation except for small scar on dorsum of left foot at site of deepest lesion.*

Plate 8.—*Same case as in Plate 5, six months later. Foot lesions have healed with repigmentation, except depigmented spots persist in small areas where deeper lesions were.*

PLATE 9.—*Foot lesions at 29 days showing deeper involvement between 1st and 2nd toes, right foot. Case 26, age 13, M.*

PLATE 10.—*Same case as in Plate 9, six months after exposure. Note persisting depigmented areas where worst lesions were.*

PLATE 11.—*Extensive lesions in 13 year old boy at 45 days post-exposure. Case 26.*

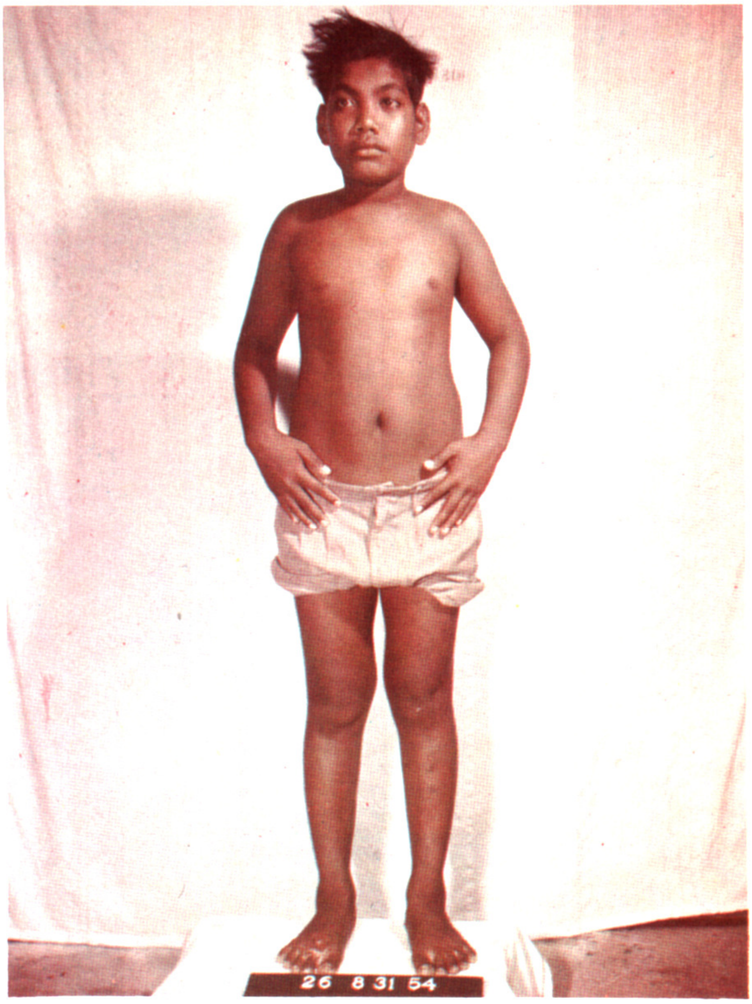

PLATE 12.—*Same boy as in Plate 11 six months after exposure showing healed lesions and regrowth of hair.*

PLATE 13.—*Desquamation of back of scalp at 28 days. Epilation occurred earlier in desquamated area. Note ulceration of left ear.*

PLATE 14.—*Same case. Epilation back of head at 46 days. Note persistent ulceration of left ear. Case 79, age 41, M.*

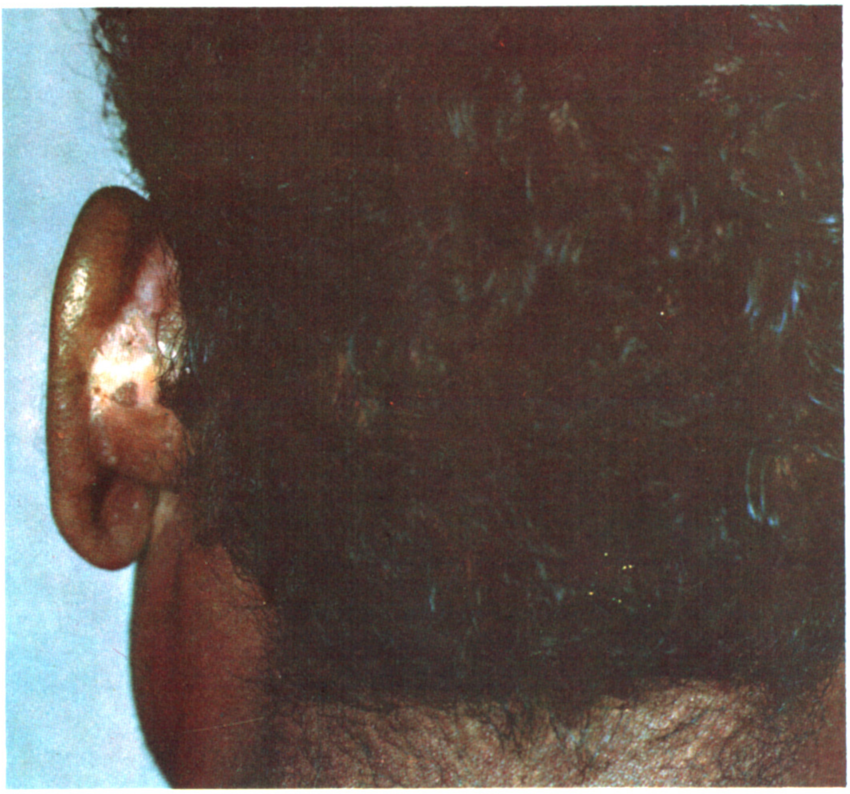

PLATE 15.—*Same case as in Plate 14 showing complete regrowth of hair of normal color and texture at six months after exposure. Ear lesion has healed with considerable scarring. See Plate 16.*

PLATE 16.—*Ear lesion shown in Plate 15 magnified 20 times. Note atrophy and scaling of scar tissue. Telangiectatic vessels can be seen in the upper part of the picture.*

Plate 17.—*Epilation in 7 yr. old girl at 28 days. Case 72.*

Plate 18.—*Same case as in Plate 17, six months after exposure showing complete regrowth of normal hair.*

Plate 19.—*Spotty epilation in boy, age 13, at 28 days. Case 26. Note scalp lesions in areas of epilation. (Same case as in Plates 9–12).*

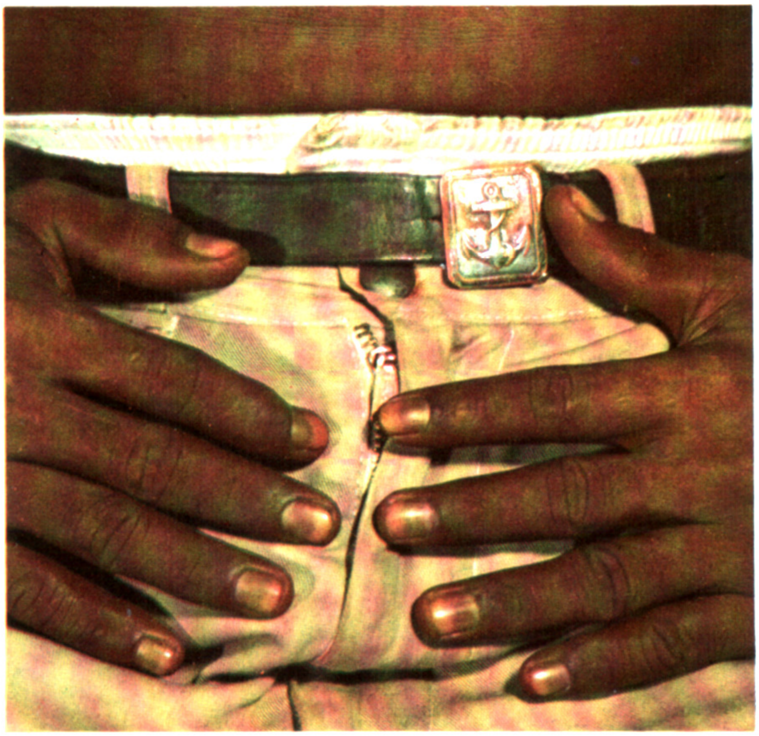

Plate 20.—*Pigmented bands in semilunar area of fingernails at 77 days.*

Table 1.1—Exposed, and Control Unexposed Groups

Group Designation	Total Number in Group	Approximate Time of Commencement of Fallout	Time of Evacuation	Instrument Readings Used in Dose Calculations	Best Estimate of Total Gamma Dose in Air (r)
Group I.—Rongelap	64	H + 4 to 6 hrs.	H + 50 hrs. (16 people) H + 51 hrs. (48 people)	375 mr/hrs., H + 7 days	175
Group II.—Ailinginae	18	H + 4 to 6 hrs.	H + 58 hrs.	100 mr/hrs., H + 9 days	69
Group III.—Rongerik	28	H + 6.8 hrs.	H + 28.5 hrs. (8 men) H + 34 hrs. (20 men)	280 mr/hrs., H + 9 days	78
Group IV.—Utirik	157	H + 22 hrs.	Started at H + 55 hrs. Completed at H + 78 hrs.	40 mr/hrs., H + 8 days	14
Marshallese, Control Group A	117				
Americans, Control Kwajalein-American	105				

Total Exposed—267; Total Controls—222

On Rongerik (Group III) a set of film badge readings were obtained which constitute the only direct evidence of total dose. Several badges worn both outdoors and inside lightly constructed buildings on the island read about 50 to 65 r, and one badge which remained outdoors over the 28.5 hour period read 98 r. Another group of badges, kept indoors inside a steel refrigerator, read 38 r.

A long fallout probably would not be uniformly heavy throughout, the first portion being the most intense and the balance decreasing with time. The total phenomenon would thus tend toward the effect of a shorter fallout. This is supported by monitor data from other nuclear events, where initially heavy fallout is reported to produce a peak of air-borne radioactivity soon after arrival, with the airborne activity level then decreasing.

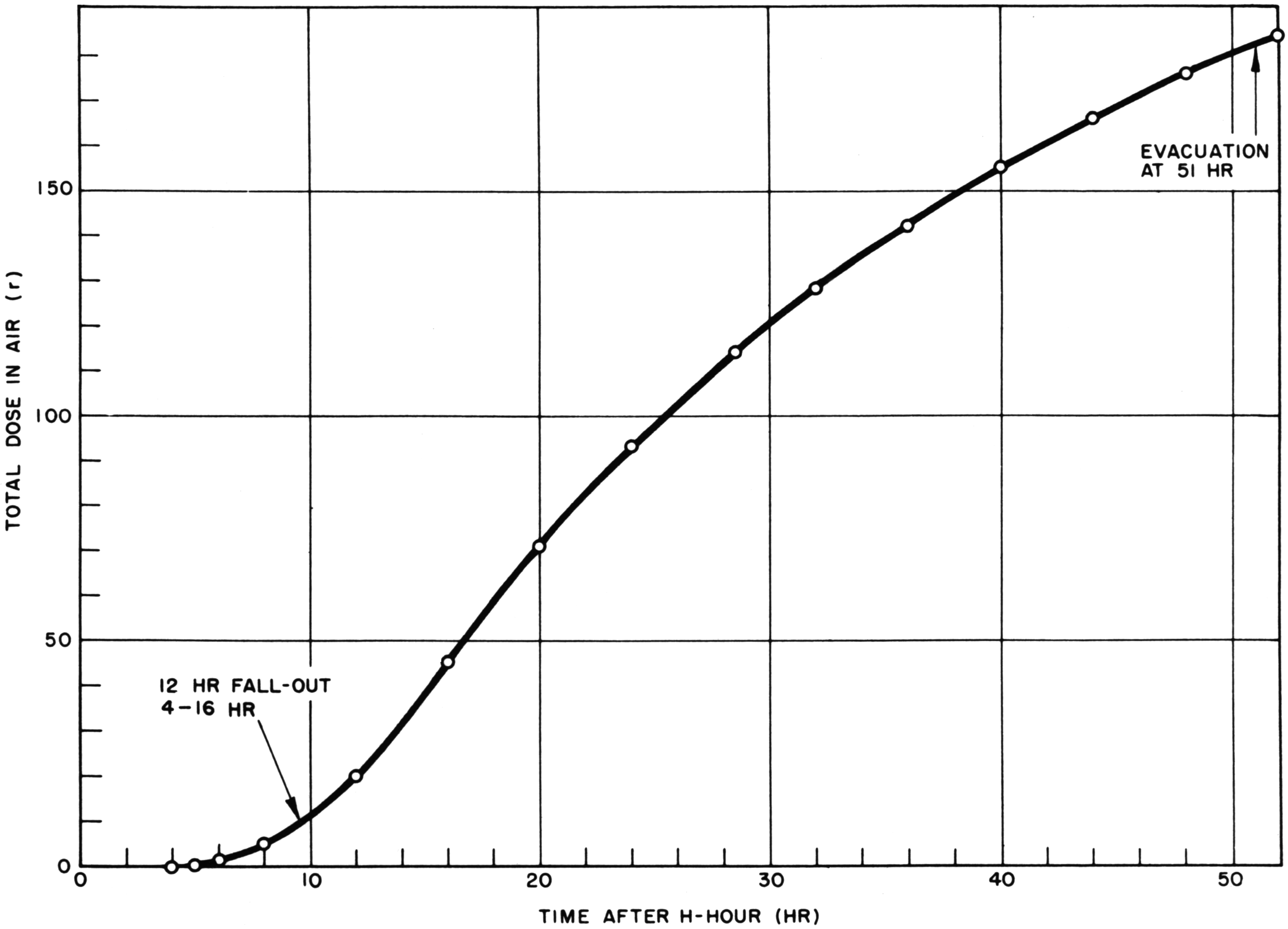

Figure 1.3—*The accumulation of gamma dose as a function of time after commencement of fallout on Rongelap*

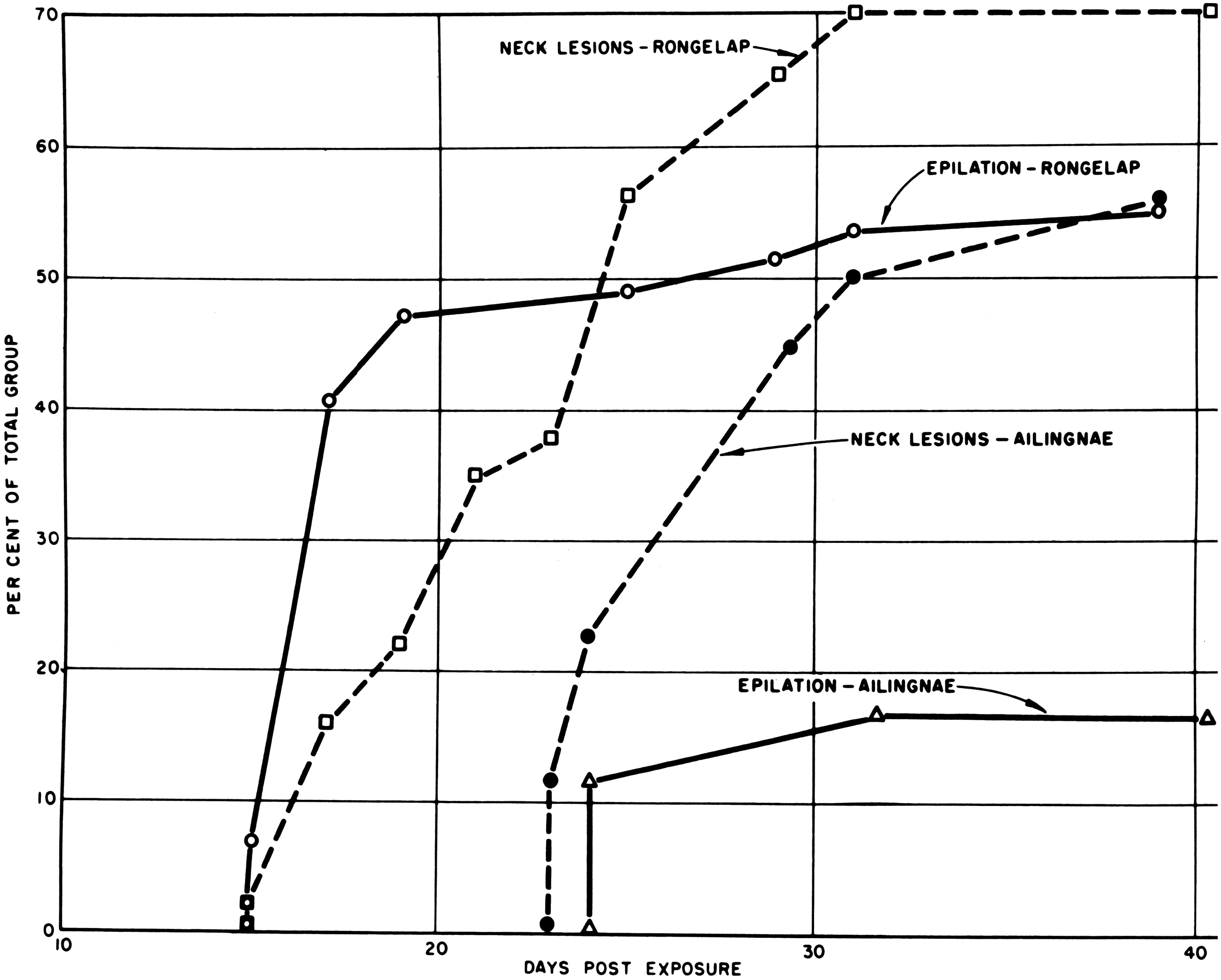

Figure 3.1.—*Comparison of the Incidence and Time of Appearance of Epilation and Neck Lesions in the Rongelap and Ailinginae Groups.*

Table 3.2.—Lesions in Ailinginae and Rongerik Groups

Type of Lesion	Ailinginae Group (18 people)		Rongerik Group (Americans) (28 people)	
	% of Total With Lesions	Mean Time of Appearance*	% of Total With Lesions	Mean Time of Appearance*
Epilation	16.7	27	3.5**	42
Lesions of:				
Scalp and face	38.9	26	10.7	32
Neck and shoulders	61.0	27	14.3	30
Back	0.0	------	7.1	28
Axilla	22.2	24	3.5	23
Antecubital fossae	11.1	28	25.0	29
Hand, wrist	5.6	38	3.5	47
Feet	16.7	33	3.5	43
Legs	5.6	44	0.0	------
Nail discoloration	77.7	38	17.9 (All Negroes)	40

*Days post-exposure.

**One case claimed slight epilation.

FIGURE 1.1—*Typical construction of the Marshallese homes to illustrate the exposure environment of the Marshallese and the lack of shielding from gamma radiation.*

Itching and burning of the skin occurred in 28 percent of Group I (Rongelap), 20 percent of Group II (Ailinginae), 5 percent of Group III (Americans), and none of Group IV (Utirik). Three people in Group I and one in Group II complained of itching and burning of the eyes and lacrimation.

About two-thirds of Group I were nauseated during the first 2 days and one-tenth vomited and had diarrhea. One individual in Group II was nauseated. In Groups III and IV there were no gastrointestinal (GI) symptoms.

BETWEEN THE 33rd and 43rd post-exposure days, 10 percent of the individuals in Group I had an absolute granulocyte level of 1000 per cubic millimeter or below. The lowest count observed during this period was 700 granulocytes/mm.[3]

Less striking fallout described as "mist-like" was observed on Ailinginae and Rongerik. Fallout was not visible on Utirik, which was contaminated to only a mild degree. The severity of the skin manifestations was roughly proportional to the amount of fallout observed.

Group	Fallout Observed	Skin Lesions and Epilation
Rongelap	Heavy (snowlike)	Extensive.
Ailinginae	Moderate (mistlike)	Less extensive.
Rongerik	Moderate (mistlike)	Slight.
Utirik	None	No skin lesions or epilation.

During The First 24–48 hours after exposure, about 25 percent of the Marshallese in the two higher exposure groups experienced itching and a burning sensation of the skin.

Skin lesions in the lesser exposed Ailinginae and Rongerik groups developed approximately one week after those in the Rongelap group, and were less severe and extensive. The Utirik group did not develop any lesions which could be attributed to irradiation of the skin. The incidence of ulcerating lesions in the different groups reflected the relative severity of the skin injury. Twenty percent of the Rongelap people developed ulcerative lesions while only five percent of the Ailinginae and none of the Rongerik people developed ulcerative lesions. Ninety percent of the Rongelap and Ailinginae groups developed lesions, compared to only forty percent of the Rongerik group. There were more lesions per individual in the Rongelap group than in the Ailinginae or Rongerik groups. A comparison of the incidence and time of appearance of epilation and neck lesions in the two groups is illustrated graphically in Figure 3.1.

a. *Shelter.* Those individuals who remained indoors or under the trees during the fallout period developed less severe lesions.

b. *Bathing.* Small children who went wading in the ocean developed fewer foot lesions. Most of the Americans, who were more aware of the danger of the fallout, took shelter in aluminum buildings, bathed and changed clothes and consequently developed only very mild beta lesions.

c. *Clothing.* A single layer of cotton material offered almost complete protection, as was demonstrated by the fact that lesions developed almost entirely on the exposed parts of the body.

3.54 Factors Favoring the Development of Lesions

a. *Areas of more profuse perspiration.* Lesions were more numerous in areas where perspiration is abundant such as the folds of the neck, axillae, and antecubital fossae.

b. *Delay in decontamination.* There was a delay of 1 or 2 days before satisfactory decontamination was possible.

Survival of Food Crops and Livestock in the Event of Nuclear War

Proceedings of a symposium held at
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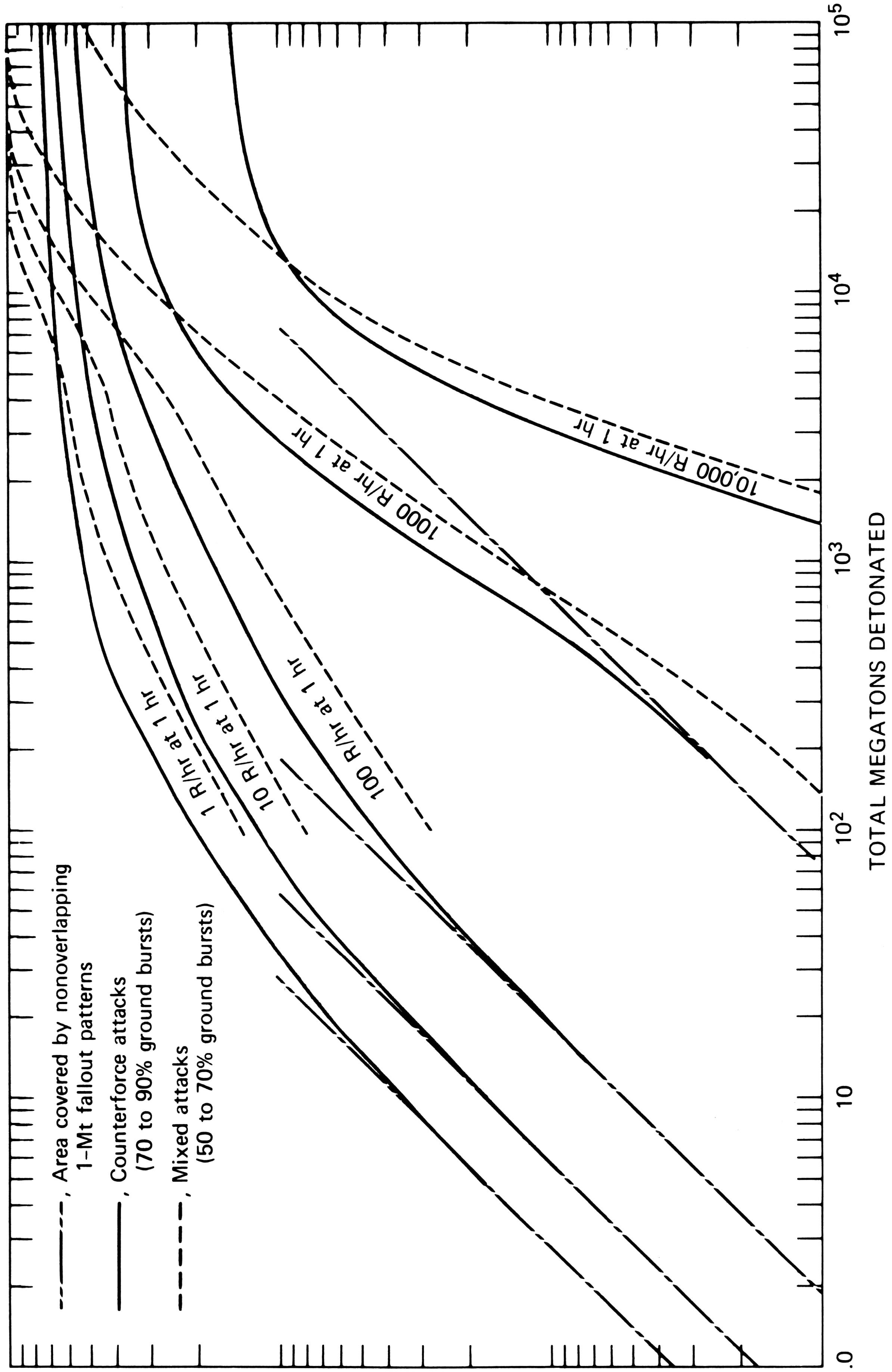

Fig. 1 Percent of area of the continental United States enclosed within selected I_S contours as a function of attack weight (50% fission weapons).

BETA-RADIATION DOSES FROM FALLOUT PARTICLES DEPOSITED ON THE SKIN

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ABSTRACT

Comparison of computed doses with the most recent experimental data relative to skin response to beta-energy deposition leads to the conclusion that, even for fallout arrival times as early as 10^3 sec (16.7 min postdetonation), no skin ulceration is expected from single particles 500 μ or less in diameter.

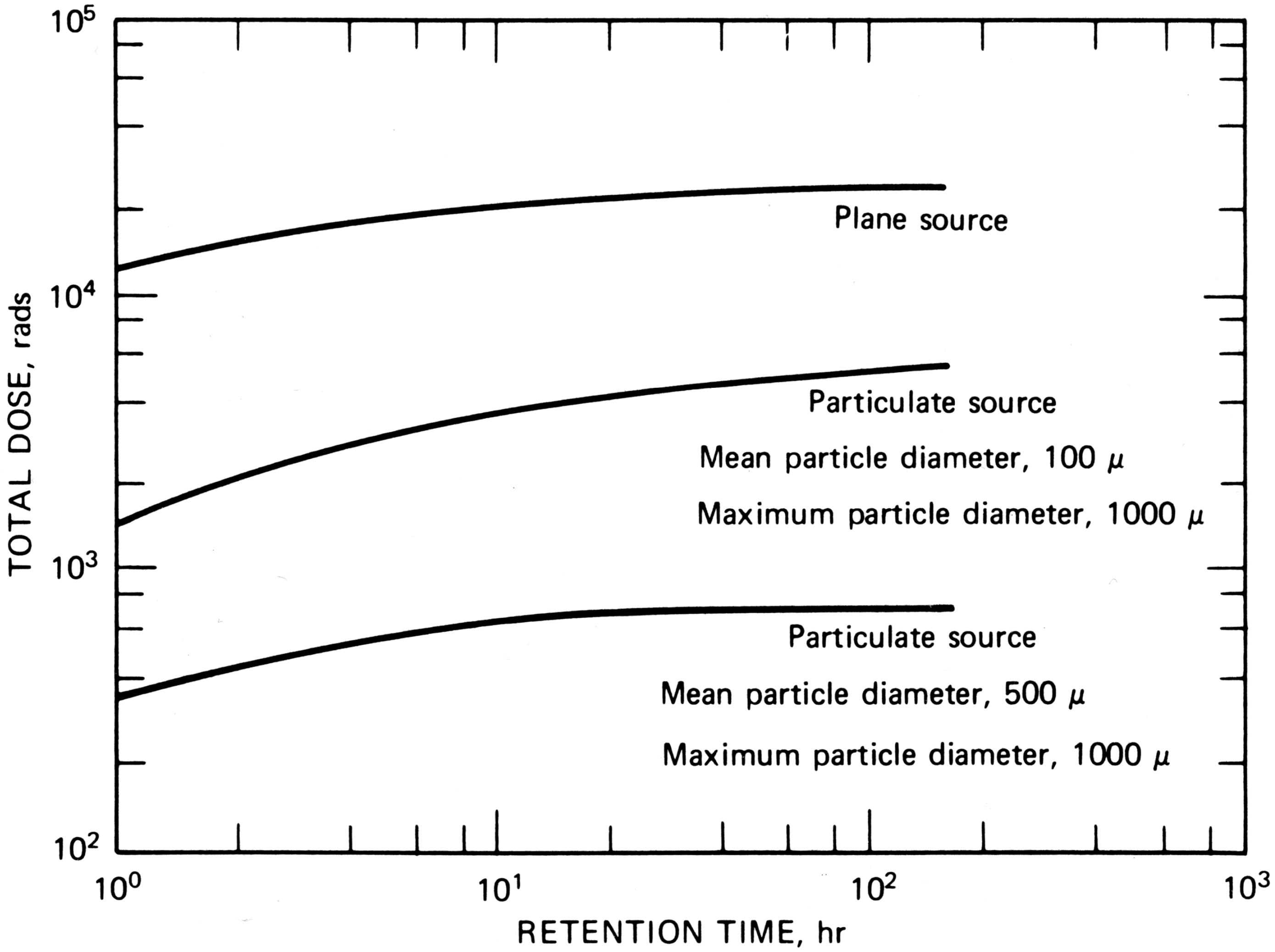


Fig. 6 Comparison between doses computed for a plane source and the corresponding values for a multiparticle source. Tissue depth, 100 μ; delay time, 10^3 sec; deposition density, 100 mg/sq ft; activity, 10^{15} fissions/cc.

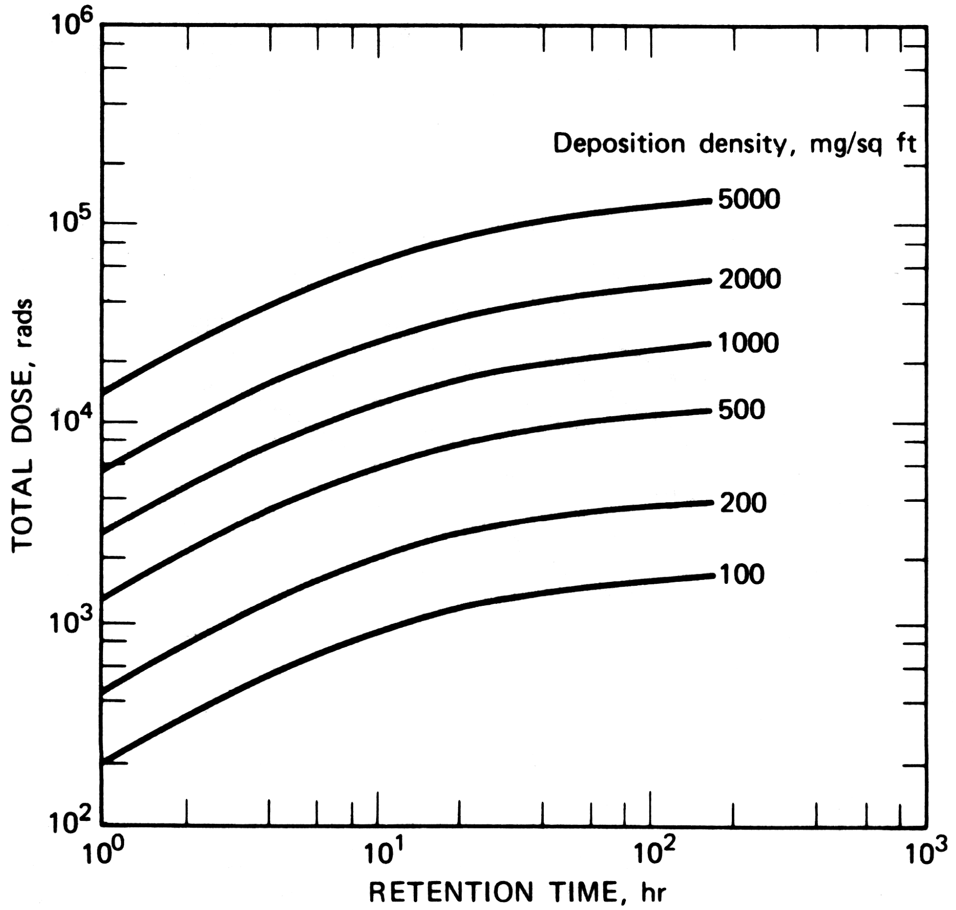


Fig. 13 Dose delivered to the skin by multiparticle fallout of 100-μ mean diameter and 1000-μ maximum diameter at an exposure starting time of 10^4 sec after detonation. Tissue depth, 100 μ.

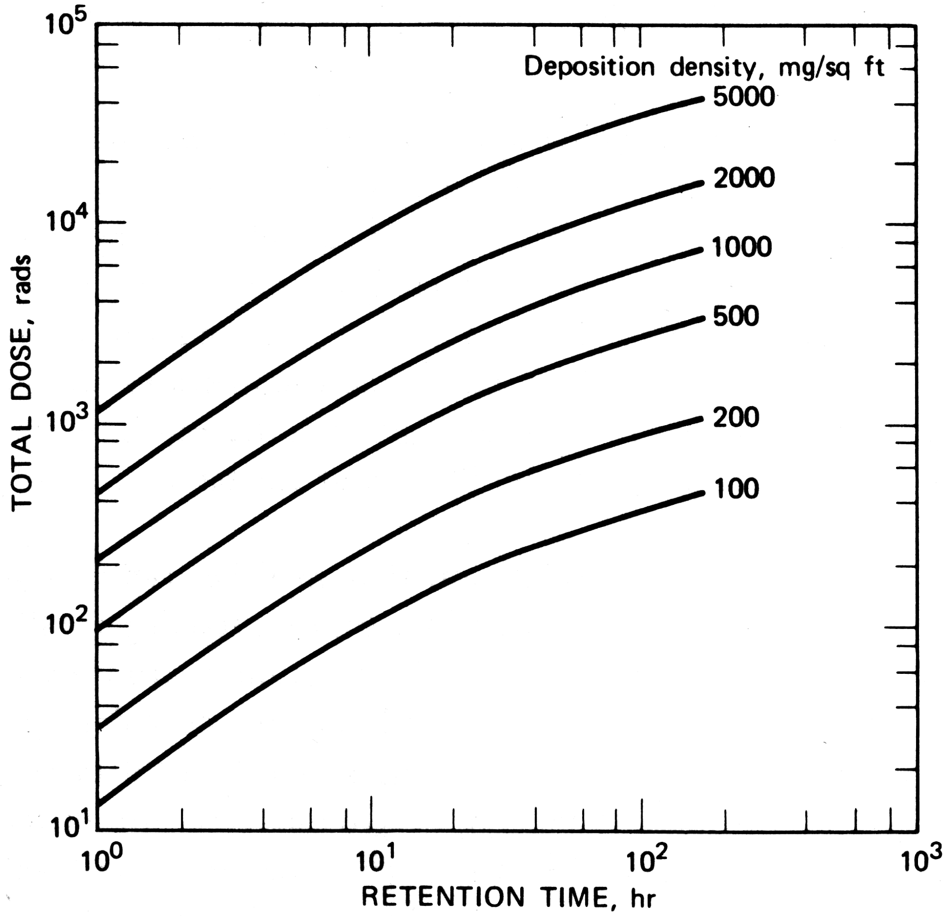
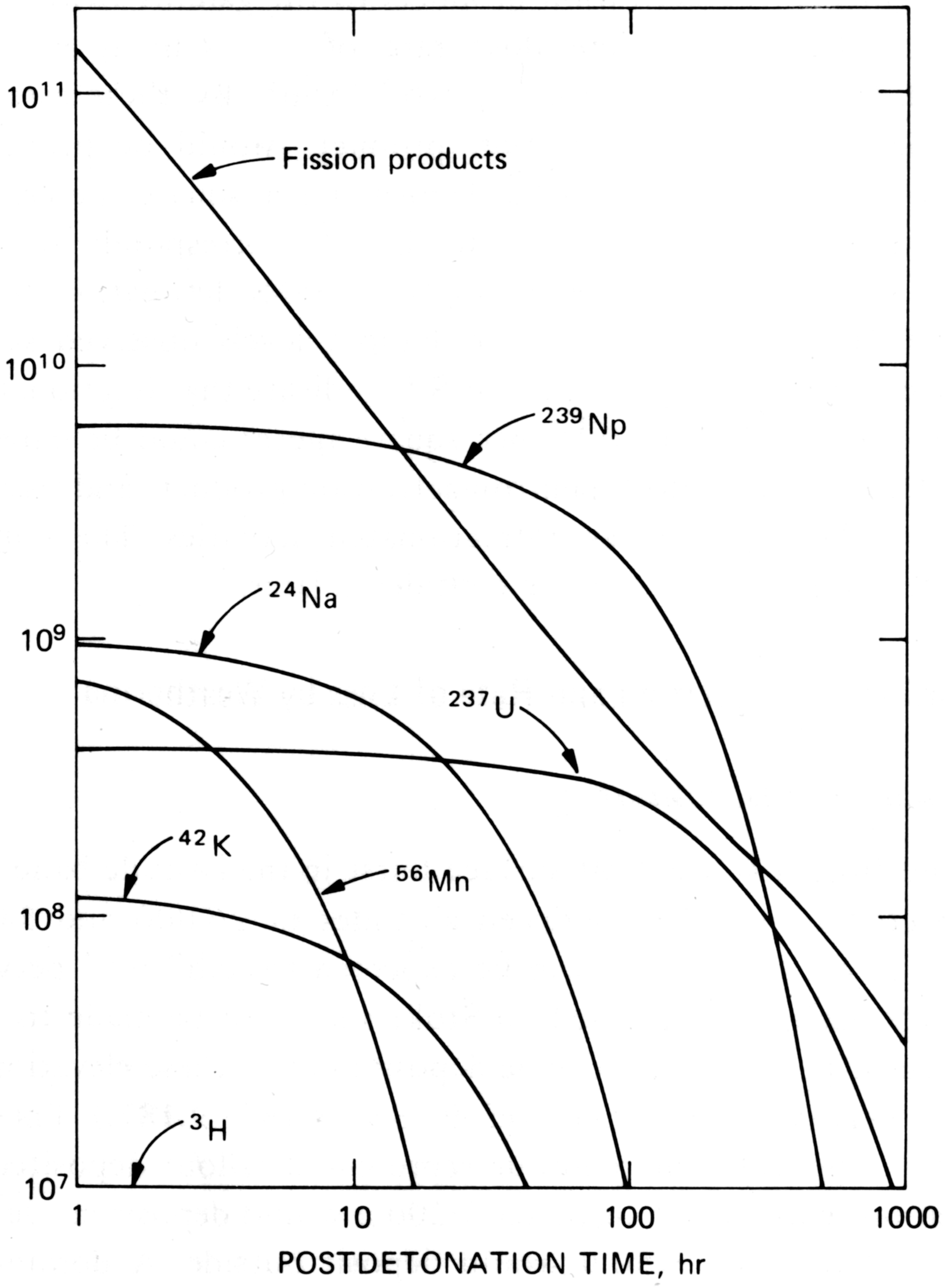


Fig. 14 Dose delivered to the skin by multiparticle fallout of 100-μ mean diameter and 1000-μ maximum diameter at an exposure starting time of 10^5 sec after detonation. Tissue depth, 100 μ.



Radioactivity from 1-Mt explosive with a fission-to-fusion ratio of 1.0.

RADIATION EFFECTS ON FARM ANIMALS: A REVIEW

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ABSTRACT

Hematopoietic death would predominate in food-producing animals exposed to gamma radiation under fallout conditions leaving animal survivors. Gamma-radiation doses of about 900 R would be lethal to 50% of poultry, and about half this level would be lethal for cattle, sheep, and swine. Grazing cattle and sheep would suffer most from combined radiation effects of skin-beta and ingested-beta radioactivity plus the whole-body gamma effects. The $LD_{50/60}$ for combined effects in ruminants is estimated to be at a gamma exposure of around 200 R in an area where the forage retention is 7 to 9%.

Either external parasites or severe heat loss could be a problem in skin irradiated animals. Contrary to early reports, bacterial invasion of irradiated food-producing animals does not appear to be a major problem. Productivity of survivors of gamma radiation alone would not be affected, but, in an area of some lethality, the productivity of surviving grazing livestock would be severely reduced owing to anorexia and diarrhea. Sheltering animals and using stored feed as countermeasures during the first few days of livestock exposure provide much greater protection than shielding alone.

The purpose of this review is to summarize the data available on the effects of ionizing radiation on food-producing animals which would be of value in predicting the effects that could be encountered from radioactive fallout in the event of nuclear war. Most of the data are limited to somatic effects of gamma and beta radiation on survival and productivity of cattle, swine, and sheep. Although much more information is available on radiation effects in small laboratory animals, it is difficult to extrapolate these data to large food-producing animals exposed to a combination of internally and externally applied radiation. Some attention is also given to measures that could be used to reduce radiation exposure of food-producing animals.

Ionizing radiation from radioactive fallout occurs principally as beta particles and gamma rays. The median beta energies are between 0.3 and 0.4 MeV, but the maximum may be up to 5 MeV. Most of the data available on beta

irradiation effects on food-producing animals were obtained by using either ^{90}Y or ^{90}Sr–^{90}Y, which have higher average energies than are characteristic of local fallout. Information on gamma irradiation was obtained principally by exposing large animals to ^{60}Co or ^{137}Cs, which have penetration characteristics similar to gamma fallout radiation.

Limited information is given on neutron exposures, and none is given on alpha radiation since neither of these emissions is expected to be of any consequence in radioactive-fallout effects on food-producing animals.

RADIATION LETHALITY

General

Exposures to gamma radiation at dose rates expected under fallout conditions causing early deaths in about half of the animals are expressed as a dose lethal to 50% in either 30 or 60 days ($LD_{50/30}$ or $LD_{50/60}$). This mortality level varies with dose rate, quality and type of radiation, animal species, and a number of other variables. The upper and lower limits of the distribution of radiation deaths for adult cattle, swine, and burros are shown by the typical sigmoid curves in Fig. 1.

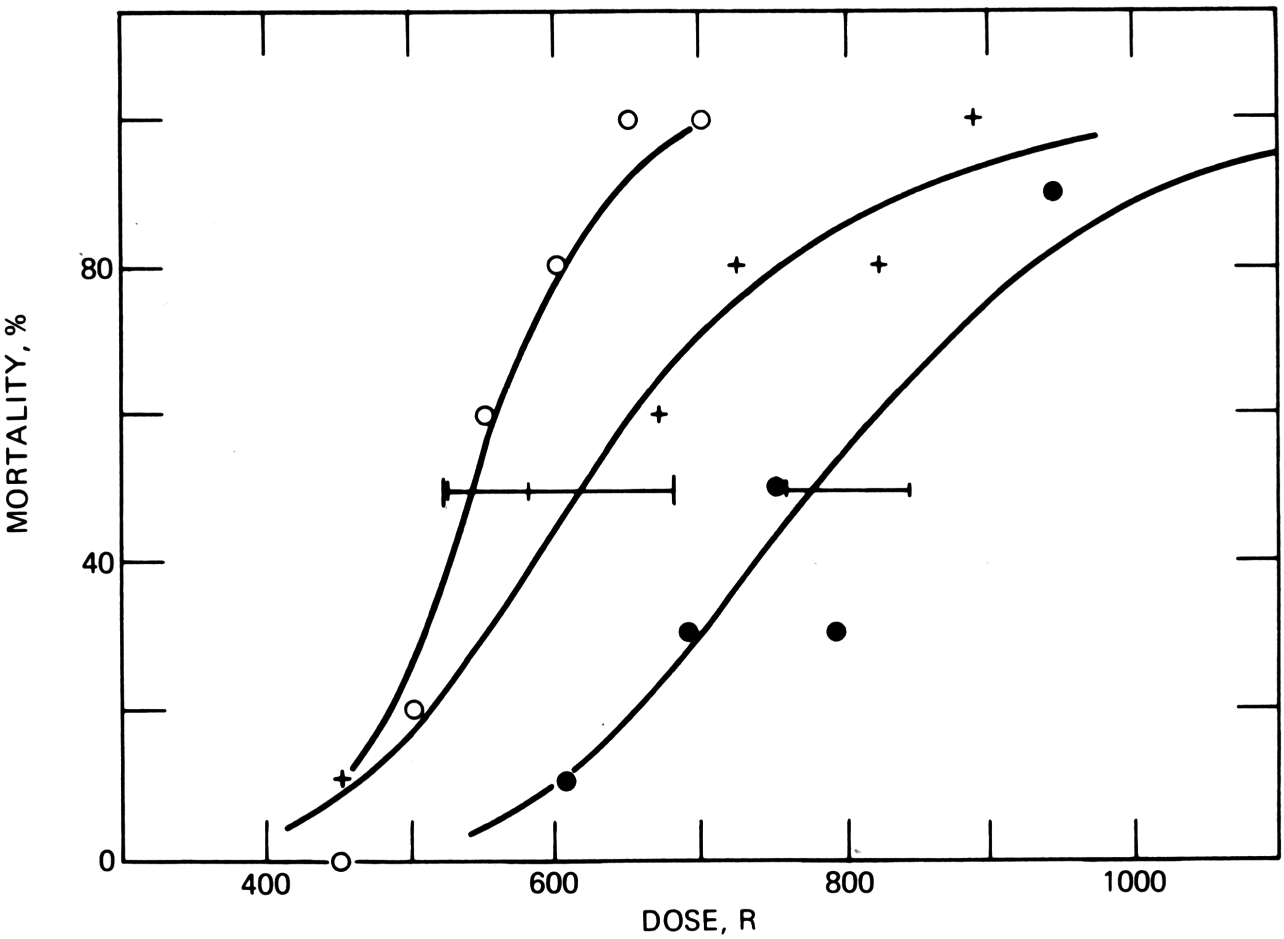

Fig. 1 Mortality of three species exposed to ^{60}Co at a dose rate between 0.5 and 1 R/min. ○, cattle; +, swine; ●, burros; ⊢⊣, 95% confidence interval. (Data from D. G. Brown, UT–AEC Agricultural Research Laboratory.)

THE SIGNIFICANCE OF LONG-LIVED NUCLIDES AFTER A NUCLEAR WAR

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ABSTRACT

The radiation doses from the long-lived nuclides ^{90}Sr and ^{137}Cs, to which the surviving population might be exposed after a nuclear war, are considered using a new evaluation of the transfer of ^{90}Sr into food chains.

As an example, it is estimated that, in an area where the initial deposit of near-in fallout delivered 100 R/hr at 1 hr and there was subsequent worldwide fallout from 5000 Mt of fission, the dose commitment would be about 2 rads to the bone marrow of the population and 1 rad to the whole body. Worldwide fallout would be responsible for the major part of these doses.

In view of the possible magnitude of the doses from long-lived nuclides, the small degree of protection that could be provided against them, and the considerable strain any such attempt would impose on the resources of the community, it seems unrealistic to consider remedial measures against doses of this magnitude. Civil-defense measures should be directed at mitigating the considerably higher doses that short-lived nuclides would cause in the early period.

It is now widely recognized that long-lived fission products would make a negligible contribution to the radiation exposure of the population in heavily contaminated areas shortly after a nuclear attack. The external radiation dose would usually be dominant, and, if simple precautions were taken to avoid the superficial contamination of foodstuffs, the entry of ^{131}I into milk would cause the only important problem of dietary contamination. Thus, for example, infants probably would not receive doses of more than 0.1 rad to bone marrow from ^{90}Sr nor more than 0.01 rad from ^{137}Cs in the weeks after a nuclear attack if they were fed continuously with milk produced in an area where the external dose rate at 1 hr after detonation had been 100 R/hr. Doses to the thyroid from ^{131}I might, however, exceed 200 rads.[1] Considerably higher doses from dietary contamination were expected until it became evident that the

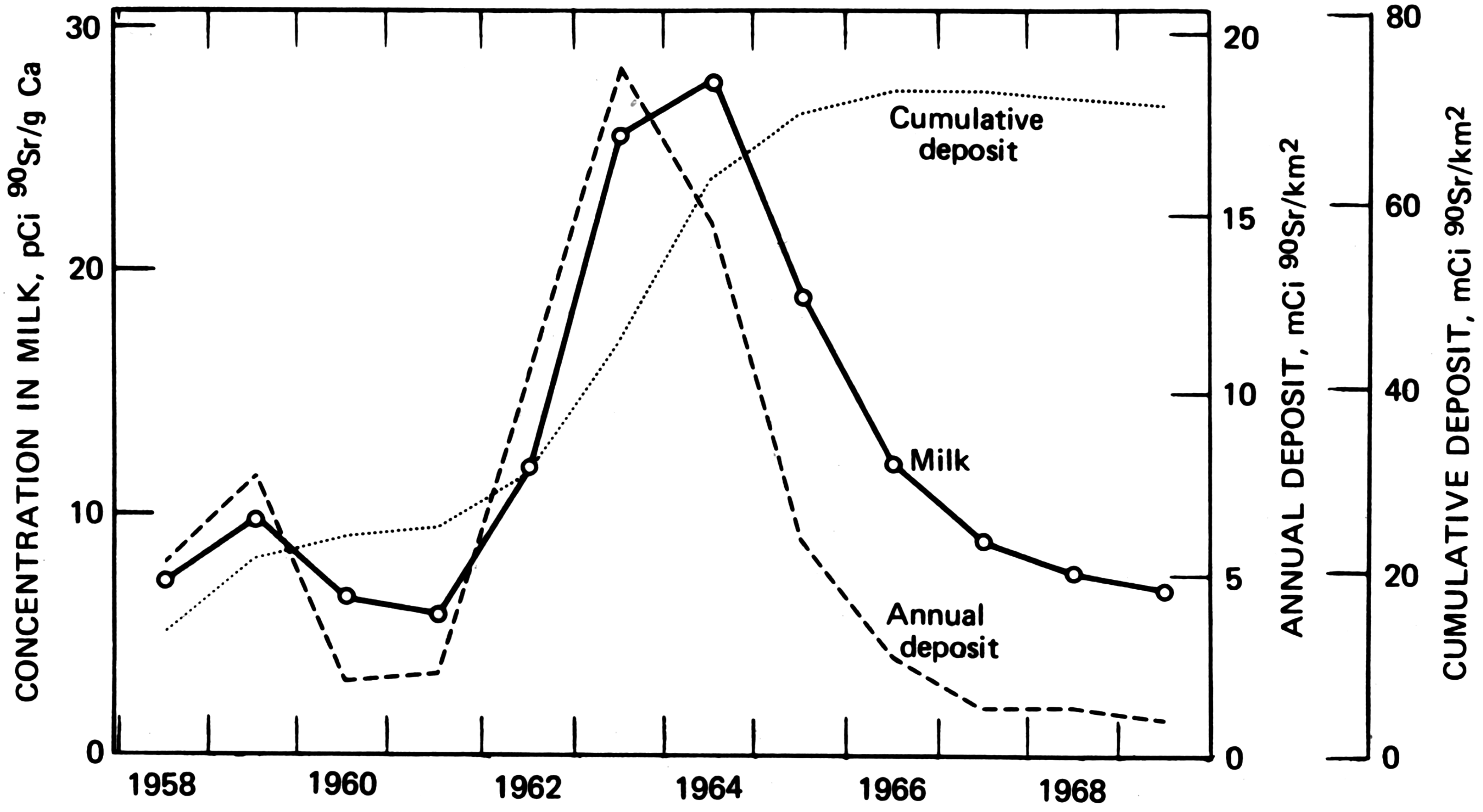

Fig. 1 Strontium-90 in fallout and milk in the United Kingdom, 1958 to 1969. Mean results of surveys of deposition and contamination in milk conducted by the Atomic Energy Research Establishment, Harwell,[31] and Letcombe Laboratory,[32] respectively.

ORNL-5037

NUCLEAR WAR SURVIVAL SKILLS

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Date Published—September 1979

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830

IMPORTANCE OF ADEQUATE WARNING

When Hiroshima and Nagasaki were blasted by the first nuclear weapons ever to be used in war, very few of the tens of thousands of Japanese killed or injured were inside their numerous air raid shelters. The single-plane attacks caught them by surprise. People are not saved by having shelters nearby unless they receive warning in time to reach their shelters—and unless they heed that warning.

TYPES OF WARNINGS

Warnings are of two types, strategic and tactical.

- **Strategic warning** is based on observed enemy actions that are believed to be preparations for an attack. For example, we would have strategic warning if powerful Russian armies were advancing into western Europe and Soviet leaders were threatening massive nuclear destruction if the resisting nations should begin to use tactical nuclear weapons. With strategic warning being given by news broadcasts and newspapers over a period of days, Americans in areas that are probably targeted would have time to evacuate. Given a day or more of warning, tens of millions of us could build or improve shelters and in other ways improve our chances of surviving the feared attack. By doing so, we also would help decrease the risk of attack.

- **Tactical warning** of a nuclear attack on the United States would be received by our highest officials a few minutes after missiles or other nuclear weapons had been launched against our country.

Most of the knowledge about beta burns on human skin was gathered as a result of an accident during the largest U.S. H-bomb test in the tropical Pacific. Winds blew the fallout in a direction not anticipated by the meteorologists. Five hours after the multimegaton surface burst, some natives of the Marshall Islands noticed a white powder beginning to be deposited on everything exposed, including their bare, moist skin. Unknown to them, the very small particles were fresh fallout. (Most fallout is sand-like, but fallout from bursts that have cratered calcareous rock, such as coral reefs and limestone, is powdery or flakey, and white.) Since the natives knew nothing about fallout, they thought the white dust was ashes from a distant volcanic eruption. For two days, until they were removed from their island homes and cared for by doctors, they paid practically no attention to the white dust. Living in the open and in lightly constructed homes, they received from the fallout all around them a calculated gamma-ray dose of about 175 R in the two days they were exposed.

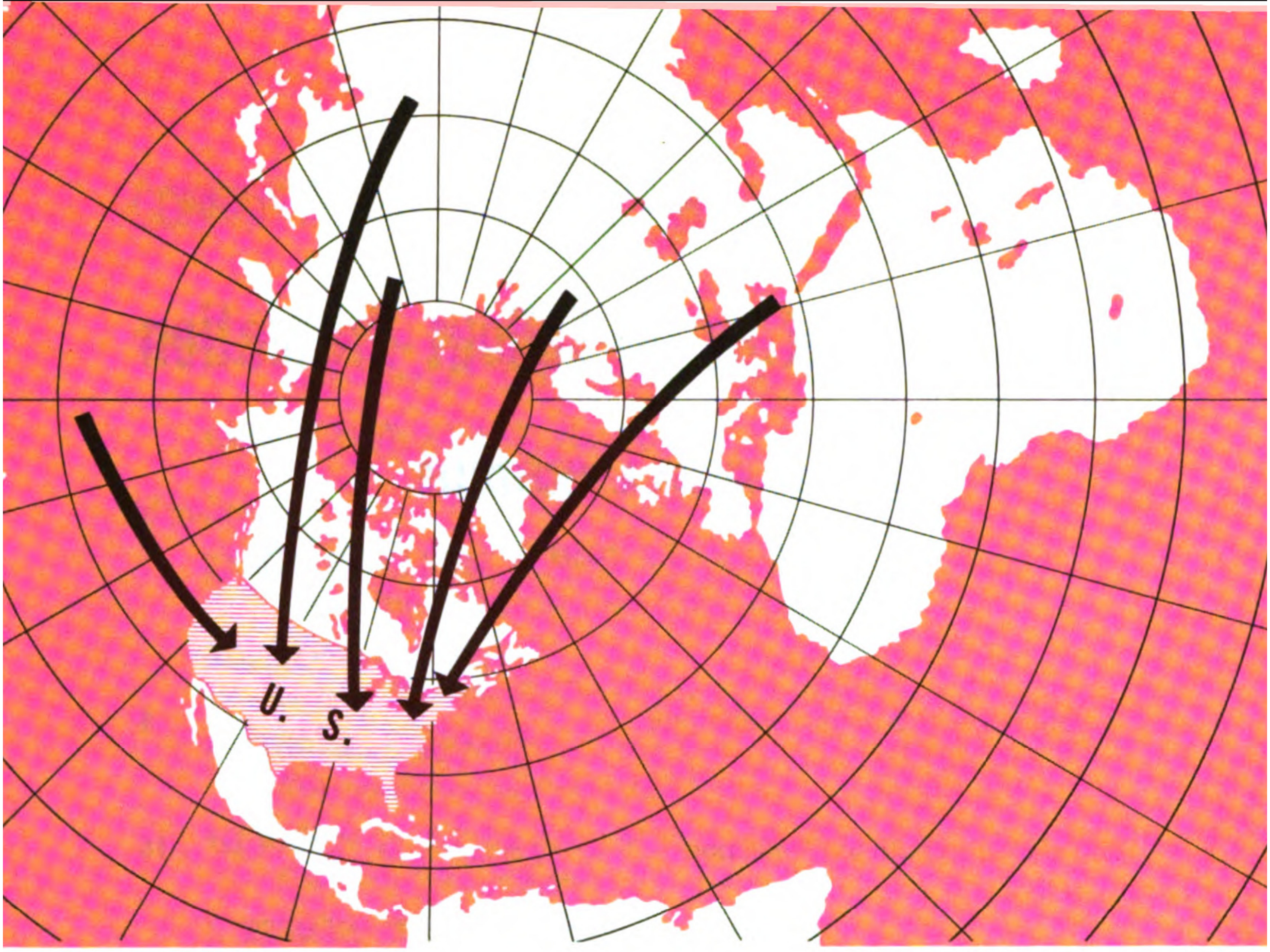
The children played in the fallout-contaminated sand. The fallout on these islanders' scalps, bare necks, and the tops of their bare feet caused itching and burning sensations after a time. Days later, beta burns resulted, along with extreme discoloration of the skin. Beta burns are not deep burns; however, it took weeks to heal them. Some, in spite of proper medical attention, developed into ulcers. (No serious permanent skin injury resulted, however.)

State of New York

Report of Committee On Fallout Protection

TO GOVERNOR NELSON A. ROCKEFELLER

February 15, 1960



I Highlights and recommendations

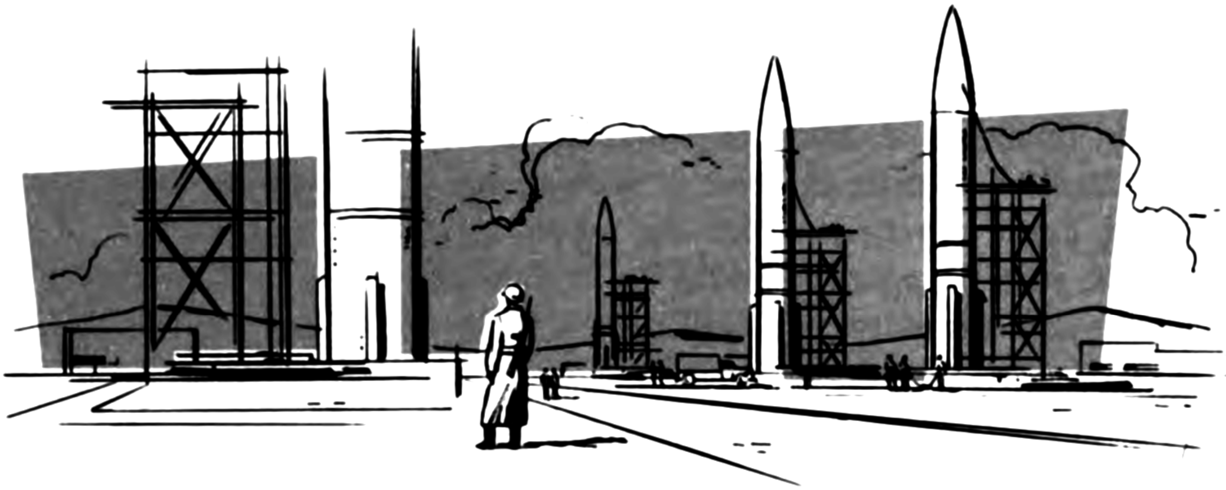
ALL IN AMERICA want peace, but the world continues in a state of tension and turmoil. World domination is the goal of our enemies and ruthless aggression may well be their policy to attain it. An enormous and growing,hostile nuclear force is poised and ready to crush us.

As recently as December 1, 1959, in Budapest, Nikita Khrushchev repeated his boast that the Soviet Union has stockpiled enough rockets and hydrogen war heads "to raze to the ground all our potential enemies."

This ominous threat was accompanied by the Soviet Premier's promise to destroy his deadly stockpiles if universal disarmament can be achieved — obviously, as in the past, on his terms.

But, what happens to us if Khrushchev's stockpiles should be used?

It is unthinkable in the face of this unprecedented danger that we should continue in our present state of almost complete civilian unpreparedness against nuclear attack. It is unthinkable because we do not need to remain unprepared. We can construct a shield that will save many millions of our people, assure our survival as a nation and preserve our American institutions and way of life.



II The case for fallout protection

THE COMMUNIST AIM is world domination—by peaceful means, propaganda, infiltration, economic power, diplomacy or seeming good will. If they can attain their objectives by these means they will not risk a major war and retaliation.

But they will use nuclear blackmail based on their boasted capabilities. And they are prepared to use force if they need to and can afford the risk.

Current and prospective good will activities, disarmament proposals, international visiting and summit conferences do not change the basic danger. But these activities can affect public opinion and attitude, and increase the difficulties of convincing people to face up to the possibility of nuclear attack and the need for some sacrifices to protect themselves against it.

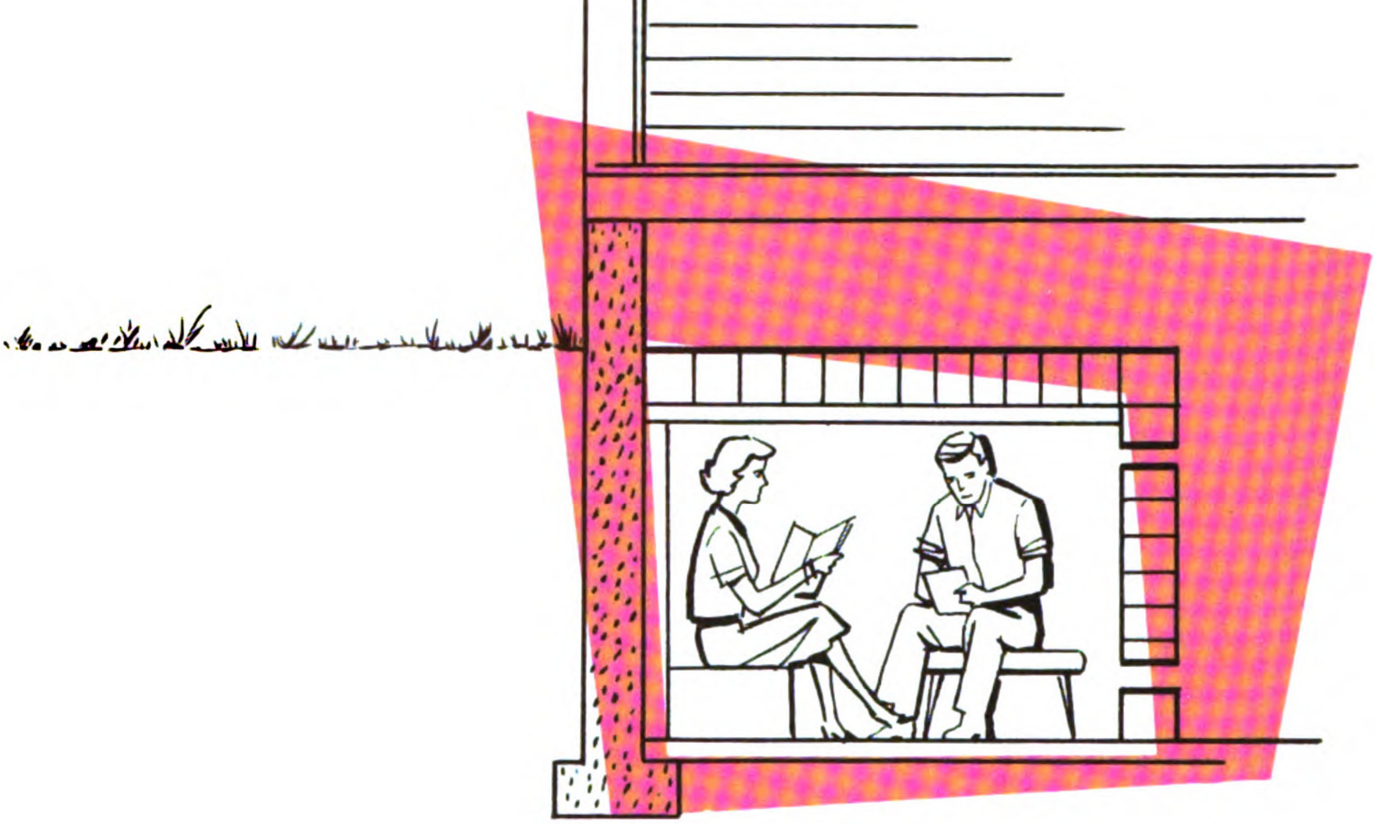
Our Secretary of State, Christian Herter, expressed this succinctly at the turn of the year:

> "Despite a new atmosphere of hopefulness for the solution of world problems, there has, in fact, been no real change in Communist intention . . . . We must not let down our guard."

Strategic considerations

Our national policy is to maintain the peace by all honorable means and to remain strong both militarily and economically.

Our military strategy has been to rely chiefly on strong and immediate retaliation to deter nuclear attack.



Compact shelters

Where it is desired to keep the cost of protection to a bare minimum, it is possible to do so, as with other necessities of life, by minimizing the size and the degree of comfort. A compact shelter of simple design and minimum dimensions will serve the purpose. This can be a masonry or concrete recess, or any shaped small space where people can sit or lie down for the first few days when high protection is urgent.

During the first two or three days of high radiation intensity, excursions into the outer basement area should be limited to the shortest possible time. Later, when the peak radiation has died down, the time spent outside the shelter can be progressively increased.

This compact type shelter can be built in a great variety of ways. Any improvisation that affords a shielded place to sit or lie down will suffice. If built in a basement below the level of the ground outside, the shielding needs to be the equivalent of an eight inch thickness of concrete. If built in a completely exposed location, it needs to be the equivalent of concrete 18 inches thick.

A very satisfactory compact shelter for a basement is of rectangular shape, built of concrete blocks and concrete plank, or poured concrete. Such a shelter is shown in the sketch above.

It can vary in size and headroom according to the number of people to be sheltered and the specific basement conditions in each case.

H-6 DECEMBER 1961

FALLOUT PROTECTION

WHAT TO KNOW AND DO ABOUT NUCLEAR ATTACK

DEPARTMENT OF DEFENSE • OFFICE OF CIVIL DEFENSE

Construction drawings on these and other family shelters can be obtained by following the instructions on the last page of this booklet.

In selecting shielding material for any shelter, sand or earth can be substituted for concrete or brick, but for each inch of solid masonry you need an inch and a half of sand or earth. Adding shielding material to a shelter will improve the protection offered by the shelter, but it also may increase the cost of the shelter.

This sand-filled lean-to basement shelter will accommodate three persons. The house itself gives partial shielding. Sandbags are used to block the end of the shelter.

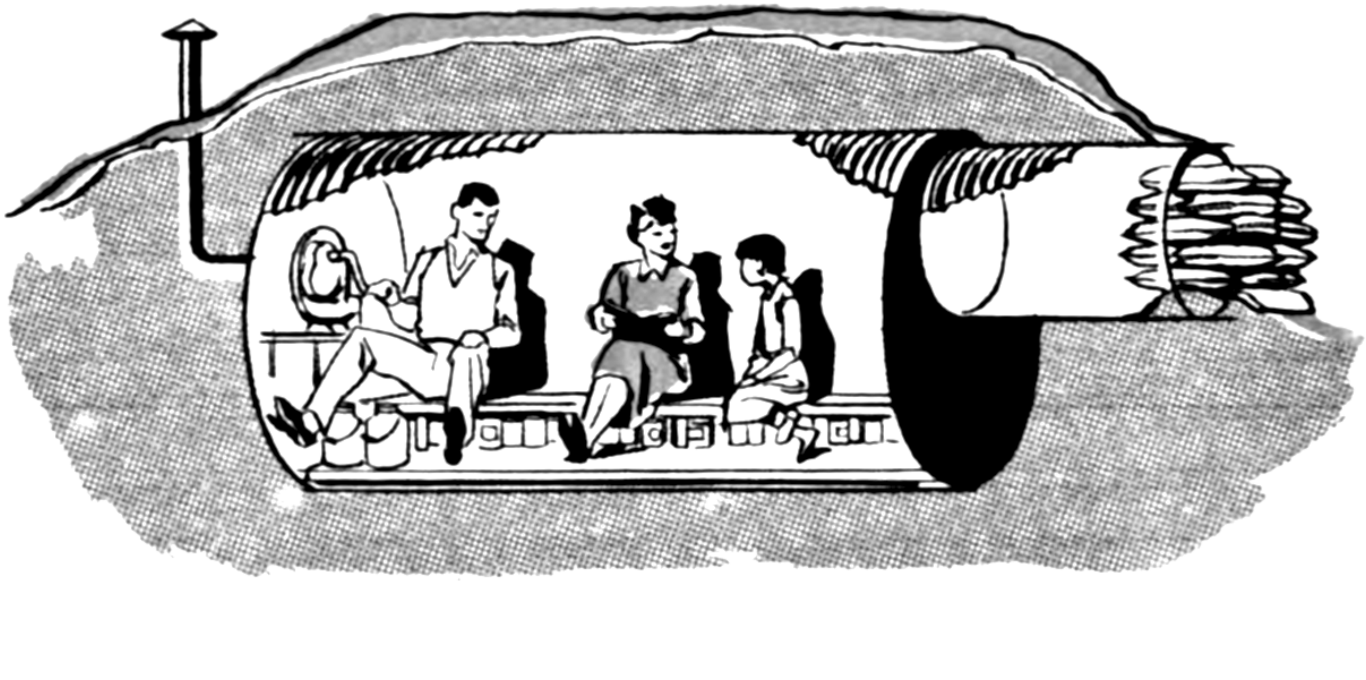
This backyard plywood shelter can be built partially above ground and mounded over with earth, or be built totally below ground level.

A gravel drain under the shelter and a ditch outside help keep it dry. The family blocks the entrance with sandbags after entering the shelter.

A number of firms have entered the home shelter field. As in any new commercial activity there are abuses. Advertising claims may be misleading; designs and products may be inadequate. Your State and Federal governments will do what they properly can to minimize these abuses, but the most effective discouragement to those taking advantage of the rising interest in home shelters is your caution and shrewdness. You will have the cooperation of the Better Business Bureau, your local Civil Defense director, and of your local, State, and Federal government officials concerned with such matters.

Trade associations that are interested in the shelter construction business have offered their cooperation in making home shelter plans available to the public and in working with others to maintain a high level of business practice. Several of these are listed on the last page of this booklet.

In the event of a nuclear attack, be prepared to live in a shelter as long as two weeks, coming out for short trips only if necessary. Fallout would be most dangerous in the first two days



This prefab backyard shelter for four can be bought for under $150. The price includes the corrugated steel-pipe unit (4-foot diameter), entry and air vent pipes.

after an attack, and even if you were inside a shelter you probably would have absorbed some radiation. Your freedom of action would depend on your radiation exposure during the critical period after the fallout descends. So, never expose yourself unnecessarily to radiation.

This four-person basement-corner shelter is made of curved asbestos-cement sheets which are covered with sandbags. Materials cost about $125.

LAST-MINUTE IMPROVISED MEASURES

In the nuclear age, nobody can guarantee you so many minutes, hours, or days of warning time. An enemy ultimatum might set a deadline; enemy bombers could be tracked while hours away; but enemy missiles could arrived unannounced. However, even the briefest warning you might get by radio or sirens would give you the precious, live-saving time to act.

The two public warning signals are:

A 3- to 5-minute STEADY TONE, meaning, turn on your radio for directions from local authorities.

A 3-minute WARBLING TONE or SHORT BLASTS, meaning take cover immediately.

There are at least two situations that could increase the severity of the danger you would face: A plan of action but no time to put it into effect, or time to act but no plan of action—no shelter, for example.

A plan but no time

Your first warning of nuclear attack could be the flash of an explosion. Don't look at it. Quick action during the next few seconds could save your life.

If you are inside, dive under or behind the nearest desk, table, sofa or other piece of sturdy furniture. Try to get in a shadow;

If you have no basement, you can improvise a shelter by digging a trench next to the house, and making a lean-to structure with house doors. Pile the dirt from the trench and other heavy objects on top of the doors and at the sides for as much radiation shielding as possible.

it will help shade you from the heat. Lie curled on your side with your hands over the back of your neck, knees tucked against your chest. Stay away from windows, or turn your back to them—they admit heat rays and also may shatter.

If you are outside, run into a building and assume the same curled-up position. If possible, face a corner.

If you cannot get into a building, seek the lowest, most protected spot, such as a ditch, gutter or depression in a lawn. Lie in the curled position. Face away from loose or breakable objects.

If you are far enough away from the explosion you may feel no effect at all. But stay put for five minutes to be sure. By then the blast effects will have passed or lost their force. You will have at least half an hour to find fallout protection.

Time but no plan

If you should receive warning of an attack but do not have a plan of action—no shelter to go to, for example—your first actions should be to guard against the hazards of fires set by the heat of a nuclear explosion. Get rid of such quick burning things as oily rags, curtains, and lampshades. Get rid of old newspapers and magazines, or stack them in the basement if you plan to improvise a fallout shelter there. Shut off main electric and gas lines until the fire danger has passed. If your house has venetian blinds, lower and shut them to bar flying glass and screen out some of the blast's fierce heat. Fill buckets, sinks, a bathtub, and other containers with water.

Then turn your attention to fallout protection. There are six general guidelines to keep in mind for improvising last-minute fallout protection:

1. A basement is usually better than aboveground floors, particularly in private residences. (In large commercial or civic buildings, however, the central areas of middle floors could offer good protection.)
2. A corner of a basement that is below ground level is better than the center of the basement.
3. On aboveground floors, improvise shelter away from outside walls.

4. When improvising shelter, keep it small. Concentrate the shielding mass immediately around and above you to conserve construction time.
5. Stay away from windows and outside doorways. They are weak points in your fallout shield. Also, windows could be shattered many miles beyond the severe blast damage area of a nuclear explosion.
6. If caught in the open, try to get to some substantial structure, such as a large commercial or civic building, a tunnel, or cave. If none of these is readily available, look for a culvert, underpass or ditch—anything that will get you below ground level—and improvise a shelter.

This man is improvising a fallout shelter in a basement corner by stacking heavy material on and at the open sides of a sturdy table. Piling dirt and other heavy material in the basement window wells will improve his margin of protection.

There are five basic first-aid rules that *everyone* should know. They are:

How to stop bleeding. The average adult body contains only six quarts of blood; the loss of one quart is serious, so bleeding has priority over all other emergencies. Apply pressure to the wound at once—with your hand if nothing else is available, although a bandage, clean cloth, or sanitary napkin will help prevent infection. But don't waste time looking for them. Don't wash the wound. Apply pressure hard and fast, bringing the edges of the wound together if you can. You may have to continue the pressure for 30 minutes.

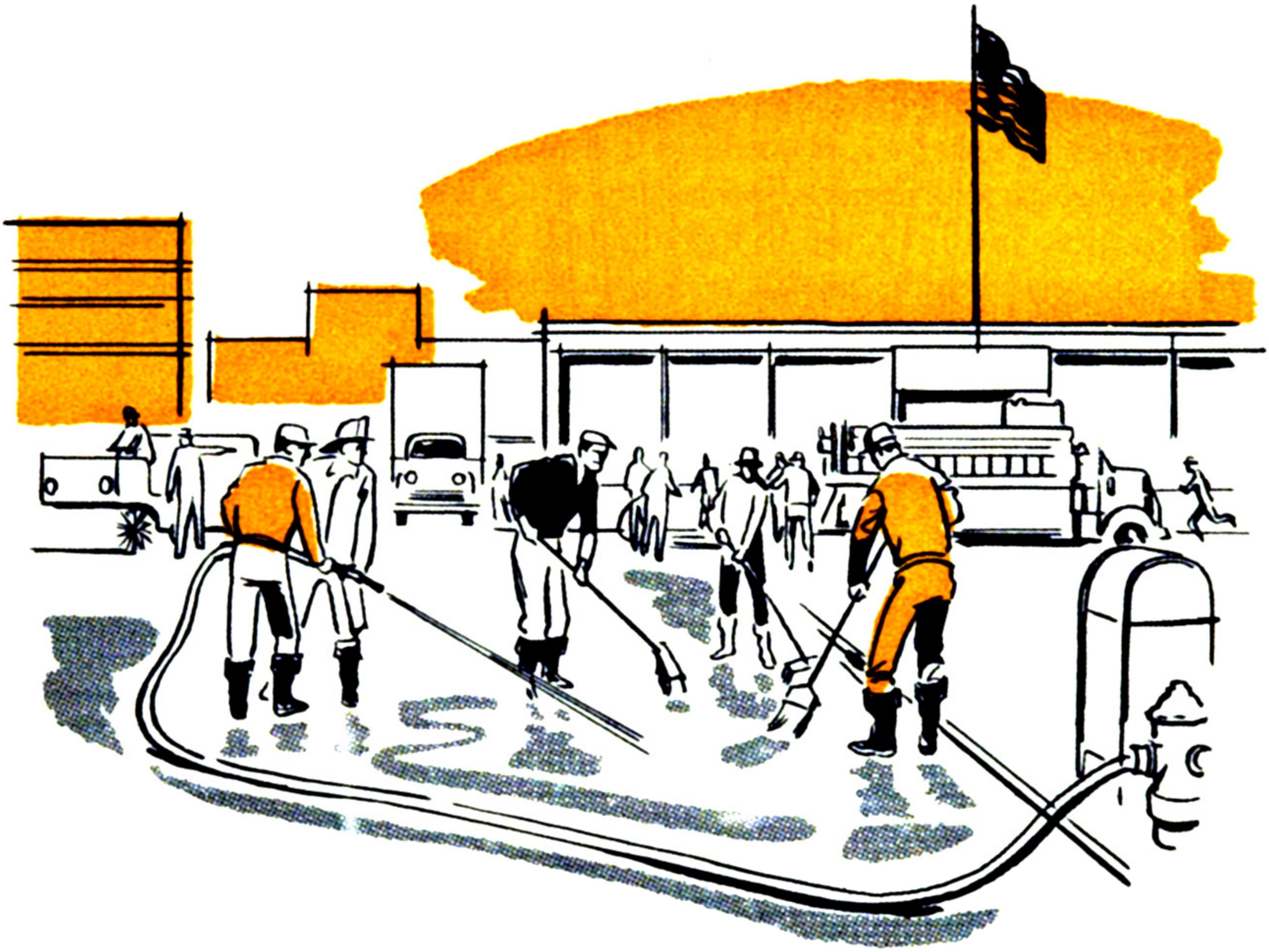
Never apply the old-fashioned tourniquet except as a last resort. It may cost the patient his limb.

CONTROL OF BLEEDING

SPLINTING

BANDAGING A BURN

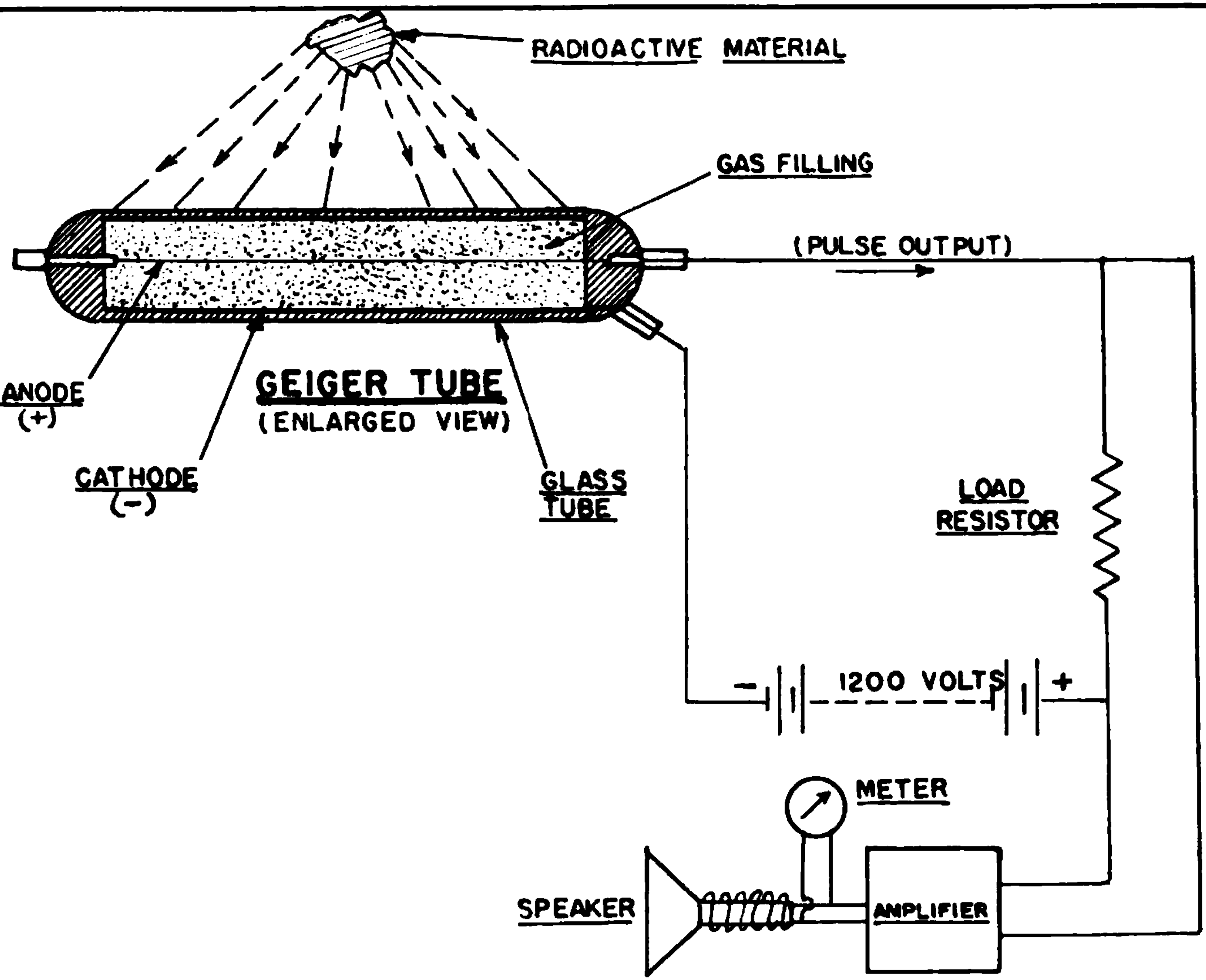
ARTIFICIAL RESPIRATION



FIRST STEPS TOWARD RECOVERY

Getting rid of fallout

The process of removing fallout particles from exposed surfaces and disposing of the particles in places where they cannot harm people is called radiological decontamination. Paved areas could be decontaminated with firehoses or street flushers, using high-pressure nozzles, and with motorized street sweepers. Roofs could be decontaminated with fire hoses. Unpaved areas could be decontaminated by scraping off or plowing under a thin top layer of soil. This could be done with large earth-moving equipment—such as motorized scrapers and motor graders—on large open areas, and with bulldozers, tractor scrapers, shovels and wheelbarrows on smaller areas around houses and trees. Another method would be to cover a contaminated area with clean earth.



CIRCUIT DIAGRAM OF G-M SURVEY METER

great value in research study of atomic particles and their characteristics. The cloud chamber is founded on the principle that water vapor condenses on an ion if the vapor is in a state of atmospheric supersaturation (Fig. 38).

Small amounts of water and air are introduced into a chamber equipped with a movable piston. The piston is

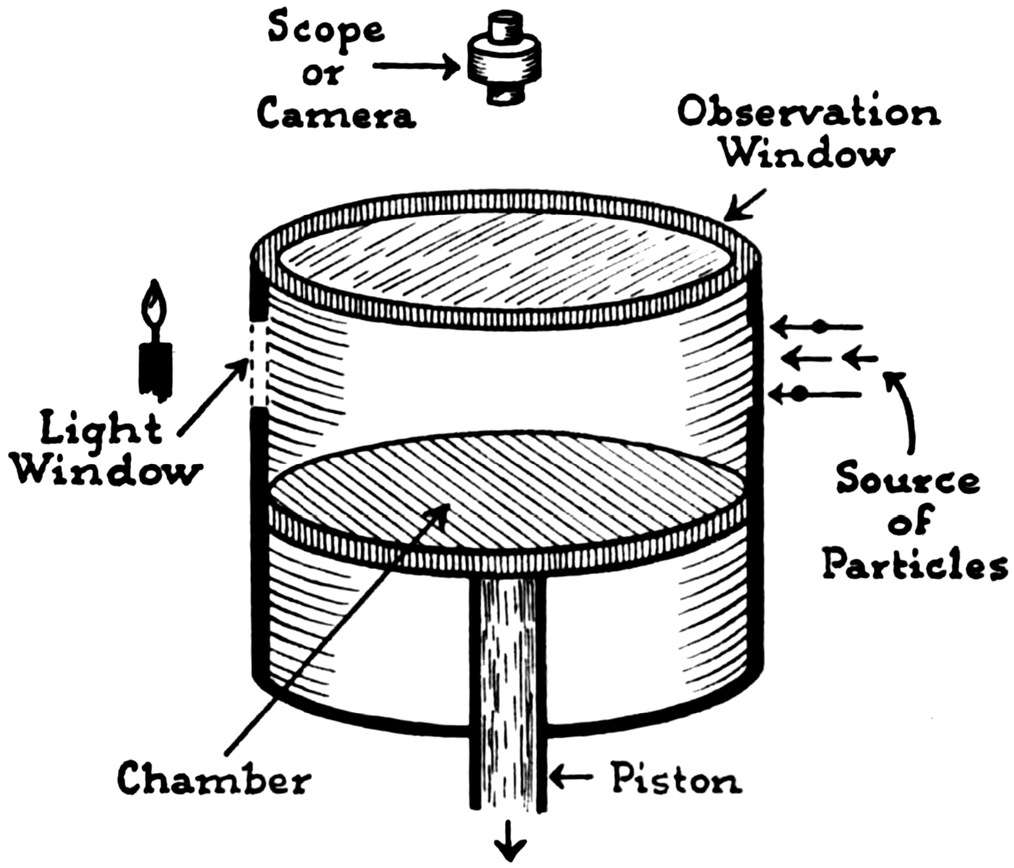


Fig. 38.—Wilson cloud chamber. Rapid reduction of pressure by withdrawal of the piston causes the air in the chamber to become supersaturated with moisture. Water vapor precipitates on the ions produced when an ionizing particle passes through the chamber. The particle therefore traces a path that can be photographed in passage.

depressed and the expansion drops the pressure and temperature so that water vapor is suspended in supersaturation. When a radioactive particle is introduced into the chamber, it produces ions on which water vapor precipitates. The particle, as it moves through the chamber, thus traces a linear track in the vapor. The track can be photographed. The character of the track is specific for the particle that produced it.

PERSONAL AND FAMILY SURVIVAL

Civil Defense Adult Education Course
Student Manual

SUPERSEDES SM-3-11, "PERSONAL AND FAMILY SURVIVAL," DATED MAY 1963

DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

The late President Kennedy, in May 1961, defined the inescapable responsibility of the Federal Government to take reasonable and practicable steps to strengthen the national civil defense capability. He stated that—

"...the history of this planet and particularly the history of the 20th Century is sufficient to remind us of the possibilities of an irrational attack, a miscalculation, and accidental war, or a war of escalation in which the stakes by each side gradually increase to the point of maximum danger which cannot be either foreseen or deterred. It is on this basis that civil defense can be readily justified—as insurance for the civilian population in case of enemy miscalculation. It is insurance we trust will never be needed—but insurance which we would never forgive ourselves for foregoing in the event of catastrophe."

Testifying before the House Armed Services Committee in February 1965, Secretary of Defense Robert S. McNamara made the point that there are—

"...three major programs which constitute our general nuclear war forces: The strategic offensive forces, the continental air and missile defense forces, and civil defense."

Secretary McNamara stressed the need for fallout shelters. In that portion of his testimony relating specifically to civil defense, he said—

"...the major issue in this area concerns the construction of a complete nationwide fallout shelter system. As I noted earlier, such a system would provide the greatest return in terms of lives saved, from any additional funds spent on damage-limiting measures."

He also said—

"...fallout shelters should have the highest priority of any defensive system because they decrease the vulnerability of the population to nuclear contamination under all types of attack."

General Earle G. Wheeler, Chairman, Joint Chiefs of Staff, said to a Special Subcommittee of the Senate Armed Services Committee, in 1963—

"Speaking both for myself as a professional soldier and for the Joint Chiefs of Staff, a fallout-protection-oriented civil defense is clearly a necessary element of the total United States national security effort. Our potential enemies have a clear capability for nuclear warfare, and we cannot discount the possibility that such a war may occur. Prudence and plain common sense dictate that we be prepared for it. An adequate program of civil defense should give our population a reasonable degree of protection as well as increasing the credibility of our military deterrent posture."

If a workbench is not available, you can improvise a small shelter area by using furniture, doors, dressers, or other materials (fig. 28). Remove doors from their hinges and place them over supports in the corner of your basement having the best protection. The supports for this improvised table can be a TV cabinet, chest of drawers, or anything that can take a heavy load. Two or three doors placed one atop the other will provide sufficient strength to support heavy loads. Place bricks, concrete blocks, sand-filled drawers, books, etc., over the doors to provide an overhead shield; and along the sides to provide a vertical shield. Use anything with weight that can be moved. The more dense the material, the better the protection.

FIGURE 28.—An improvised basement shelter.

Drinking-water is required for survival. It is also useful as a shielding material. A collapsible children's swimming pool filled with water and located over the best corner of your basement will help improve the fallout protection. A bathtub, if suitably located, can also be used for this purpose, as shown in Figure 29.

If you have nothing better to improve the shielding over the corner of your basement, stack the heaviest furniture you can find over the area. Use kitchen appliances, dressers, television sets, or drawers filled with sand. Pack them together as tightly as possible. Books and magazines can also be placed on top of the furniture. Figure 30 shows a first-floor corner room in which this has been done.

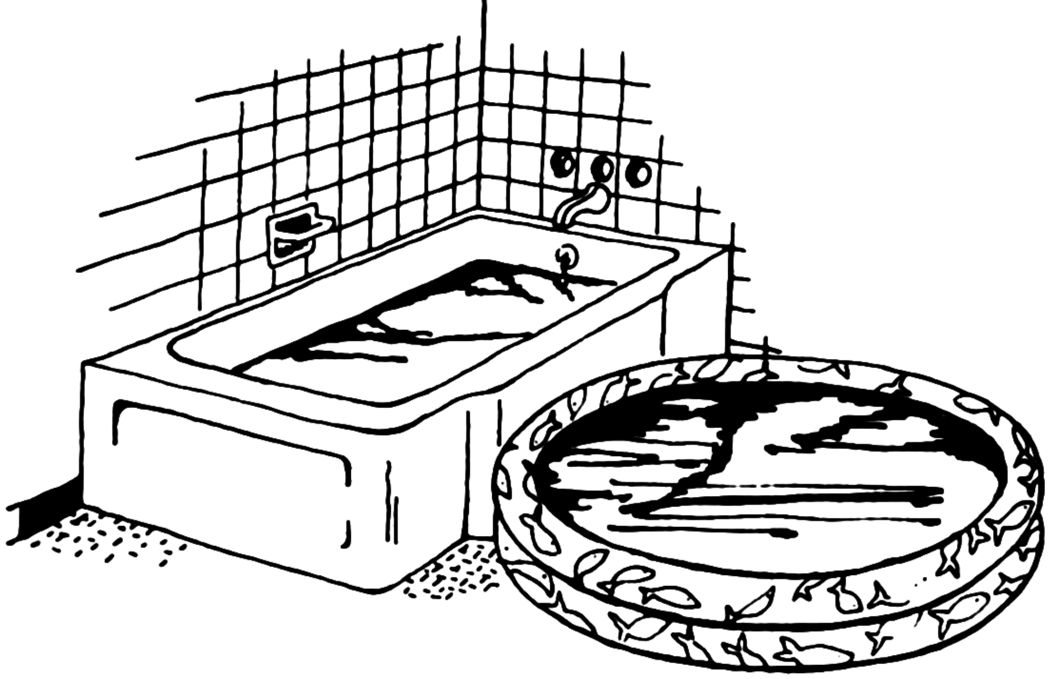


FIGURE 29.—Tubs or wading pools of water provide overhead protection.

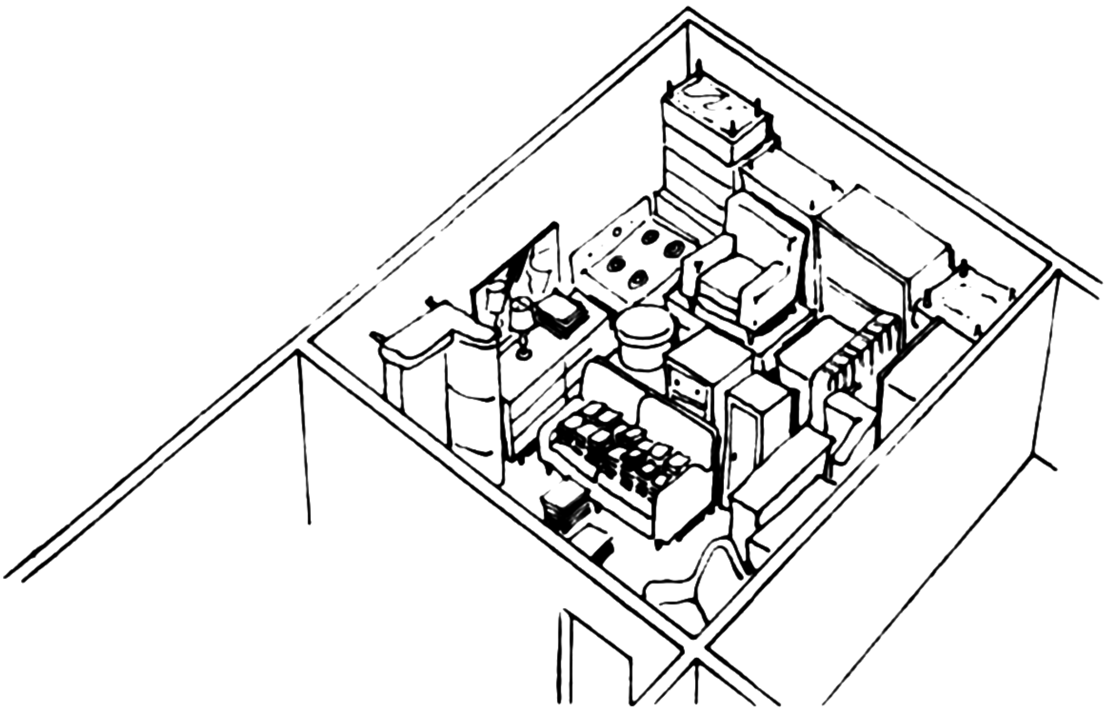


FIGURE 30.—Heavy furniture may be used for overhead protection.

Homes Without Basements

Few homes without basements provide adequate fallout protection. Therefore, if your home does not have a basement, you should plan other fallout protection if possible. There may be public fallout shelter which you can use. If not, you may be able to make use of fallout protection in a building near your home. Friends and neighbors, for example, may arrange to gather together for fallout protection in the home of one of the families that has a basement.

If these solutions are not feasible, the best means of providing adequate fallout protection, in the absence of a basement, is the

construction of a low-cost fallout shelter in the backyard. Figure 31 shows two such low-cost shelters. The plywood box shelter will cost about $100 for materials, while the steel culvert materials will cost about $150. Both of these shelters may be enlarged to provide for more people or greater comfort at a corresponding increase in cost.

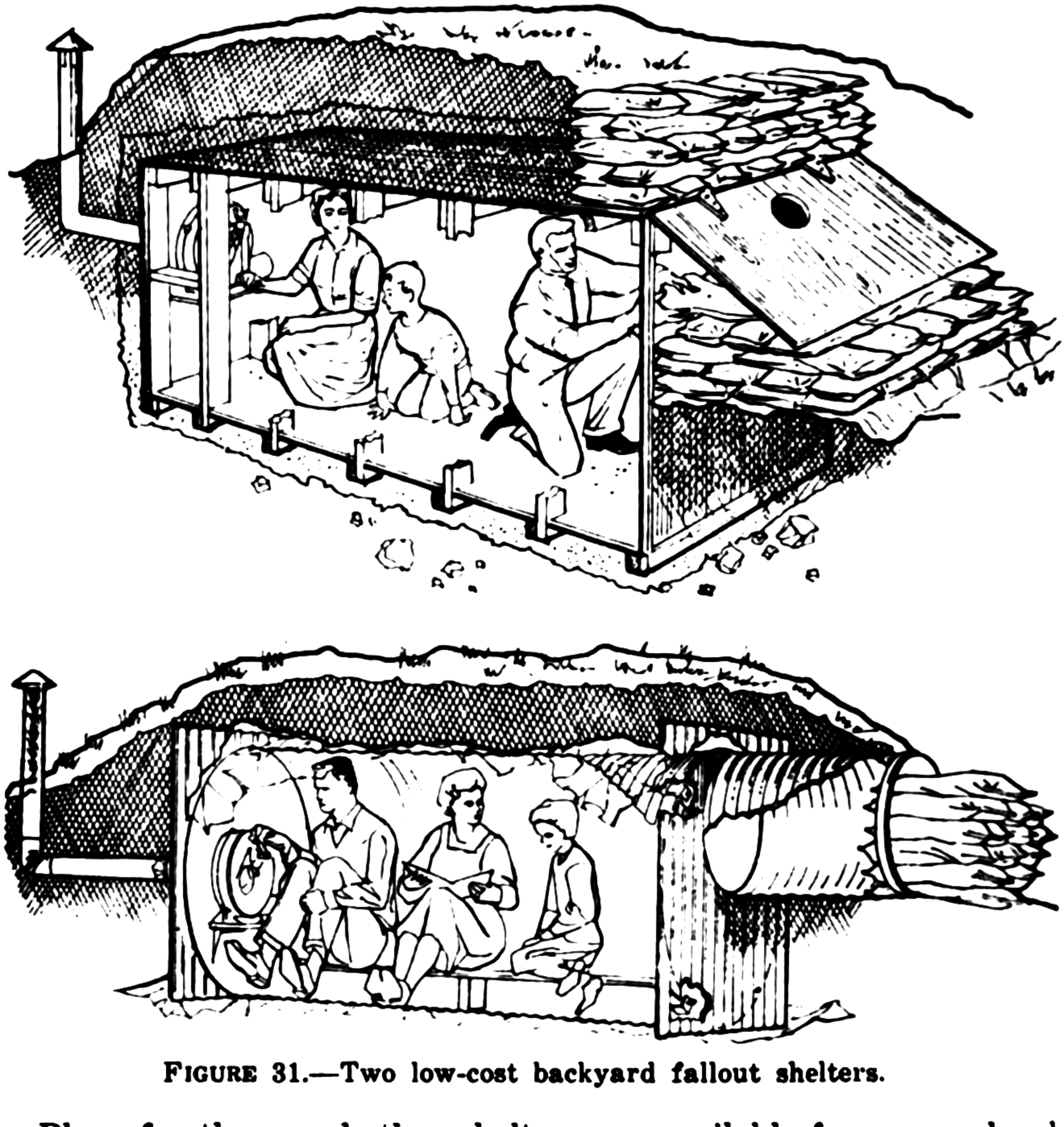


FIGURE 31.—Two low-cost backyard fallout shelters.

Plans for these and other shelters are available from your local civil defense director.

Improvising Fallout Protection Without Basements

If you do not have a public shelter available to you, your home does not have a basement, and you have not provided yourself with a fallout shelter, there are still last-minute actions which you can take to gain some fallout protection. While uncomfortable, and in some cases offering less protection than is desirable, such improvised shelter could save your life.

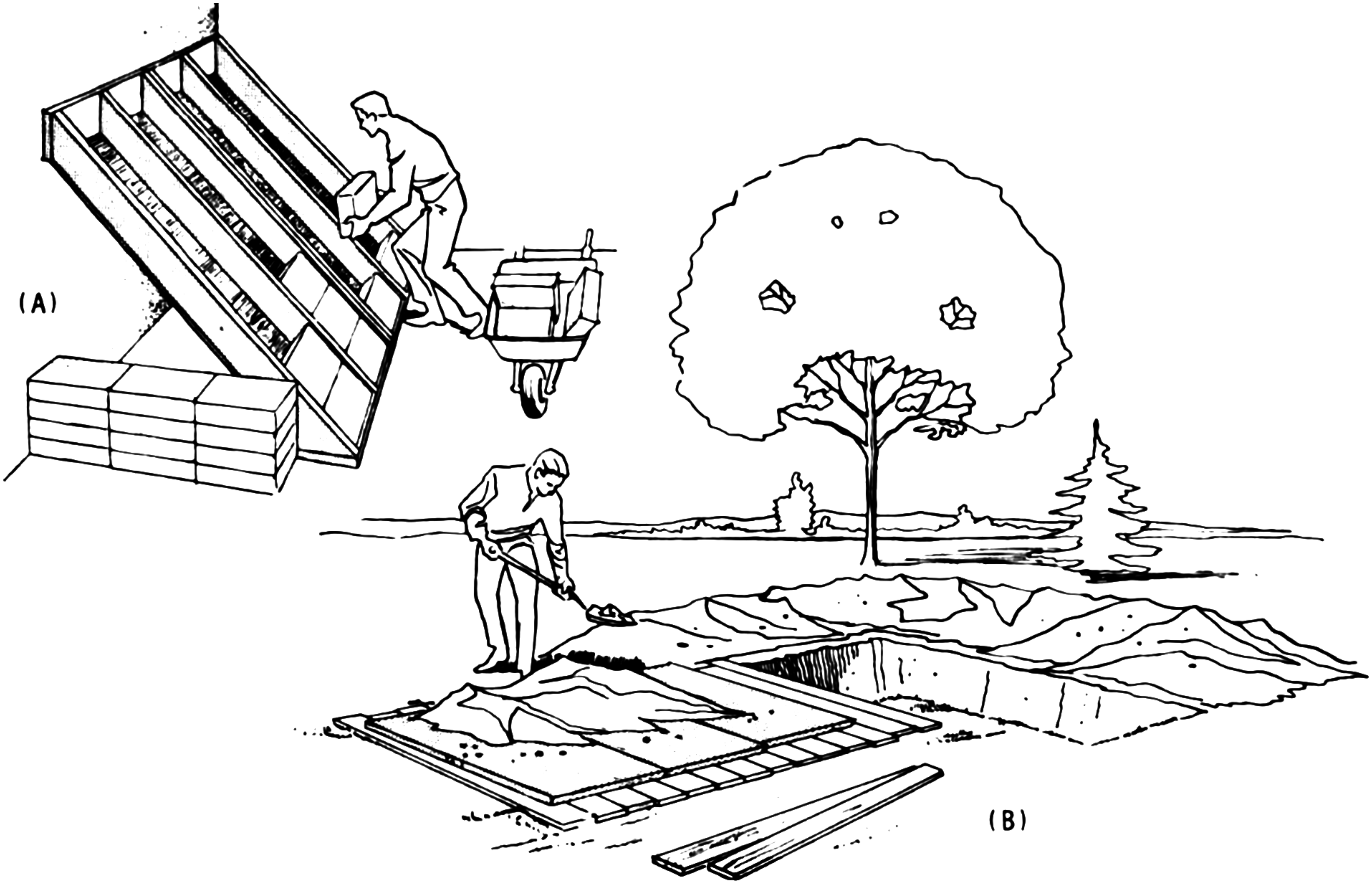


FIGURE 33.—Improvising fallout protection outside: (a) Lean-to shelter; (b) "L" shaped trench.

The time available to find protection from fallout depends upon a number of variables. The key considerations are to take shelter in a building or other structure as soon as possible and to keep radiation exposure to a minimum.

Upon warning of attack—and if there is time before seeking shelter—householders should quickly guard against the hazards of fires that could be set by the heat of a nuclear explosion. Shut off household appliances. If there are venetian blinds at the windows, lower and shut them to bar flying glass and to screen out some of the nuclear heat. Fill buckets, sinks, bathtubs, or other available containers with water.

You should keep these six general guidelines in mind in seeking last-minute fallout protection (in the event prepared shelter might be unavailable, or too far away for you to go to):

1. A basement is usually better than aboveground floors, particularly in private residences. (In large commercial or civic buildings, however, the central areas of middle floors offer good protection.)
2. A corner of a basement that is below ground level is better than the center of the basement.
3. On aboveground floors, an improvised shelter should be situated away from outside walls.
4. A small, improvised shelter can provide some protection. The shielding mass should be concentrated immediately around and above the occupant to conserve construction time.
5. Stay away from windows and outside doorways, because these are weak points in the fallout shield. Also, windows could be shattered, even though located many miles beyond the severe blast damage area of a nuclear explosion.
6. If caught out in the open, try to get to some substantial structure such as a large commercial or civic building, a tunnel, or cave. If none of these is readily available, look for a culvert, underpass, or ditch—anything that will permit concealment below ground level—and improvise a shelter.

Livestock left in the open—unprotected—would face three hazards: gamma radiation from the area around them; beta radiation from fallout particles sticking to their skins, or hides; and internal radiation from fallout on the grass they ate. In areas subjected to only moderate fallout, some or all of the livestock probably would survive. The effects of gamma radiation would be the controlling factor. Fortunately, only a fraction of the fallout from surface nuclear explosions over typical soil or rock could be expected to stick to foliage. Fallout is only partially soluble in water and most of the particles would soon sink to the bottom of a stream or pond, and the dissolved material would be greatly diluted. The hazard to animals from fallout taken into the body with foliage or water seems to be less serious than once thought. Some of the radioactive material of the ingested fallout is absorbed in the body and concentrated in bones or glands. Some appears in the milk of producing dairy cattle.

When radiation levels have decreased enough to permit care of unsheltered livestock, they should be supplied with uncontaminated feed (stored) if possible until wind, weather, and decay have removed most of the fallout from the grass or until new growth of grass overshadows the old.

FOOD FROM EXPOSED AND CONTAMINATED CROPS AND ANIMALS

Animals that have been in barn or shelter, and have had only stored feed and uncontaminated water, would be excellent sources of food. Meat, dairy, and poultry products should be wholesome, in the full sense of the word.

Apparently healthy animals that have been unprotected can still serve as sources of food as needed.

If needed for food during the emergency period, an animal could be slaughtered and used, since the meat would not be likely to contain concentrations of radioactive substances that would be dangerous to humans. The U.S. Department of Agriculture, Meat Inspection Division, has developed procedures to be used by its inspectors to assure wholesome supplies of meat.

Milk can be used as required to meet essential nutrition needs. If it is not required to be used immediately to sustain life, milk from cattle that have grazed on contaminated grass might be processed into cheese and other dairy products, and stored until its radioactivity has "decayed" to more acceptable levels. Crops

ready for harvest at the time of attack might be lost to spoilage if local radiation levels were high enough to delay harvesting work. However, the majority of crops nearing maturity at the time of fallout arrival could be harvested and used. Normal food processing, peeling, threshing, washing, etc., will remove all or most of the fallout which might be present. In any case, studies indicate that the food and water contamination problem during the early postattack period is relatively minor compared to the problem of external exposure to fallout radiation. In the later postattack period, the hazard from ingested radioactive material may predominate.

Ample safe food stocks are available for use during the emergency period. In some areas, distribution of these stocks may be a temporary problem. In this case, a hungry or thirsty person or animal should not be denied food or water because of radioactive contamination. During the recovery period, precautions against long-term hazards such as strontium 90 will be taken as needed.

SUMMARY: SURVIVAL ON THE FARM

Survival on the farm—the survival of most farm families and agricultural production—can be achieved. Required are: fallout protection for farm families and livestock; application of farm safety procedures, including work schedules to control necessary exposures to radioactive fallout while caring for livestock; and an effective civil defense capability in local government, including radiological defense services and expert agricultural guidance.

WT-915

This document consists of 172 pages

No. 238 of 240 copies, Series A

OPERATION CASTLE

Project 2.5a

DISTRIBUTION AND INTENSITY OF FALLOUT

REPORT TO THE SCIENTIFIC DIRECTOR

by

R. L. Steton
E. A. Schuert
W. W. Perkins
T. H. Shirasawa
H. K. Chan

This document regraded
From SECRET
To UNCLASSIFIED
Date 14 July 82
Authority DNA LTR 6/14/82

(The Castle-Bravo 15 megaton H-bomb test of 1 March 1954, which contaminated a Japanese tuna trawler and islanders)

January 1956

[redacted]

[redacted]

U. S. Naval Radiological Defense Laboratory
San Francisco 24, California

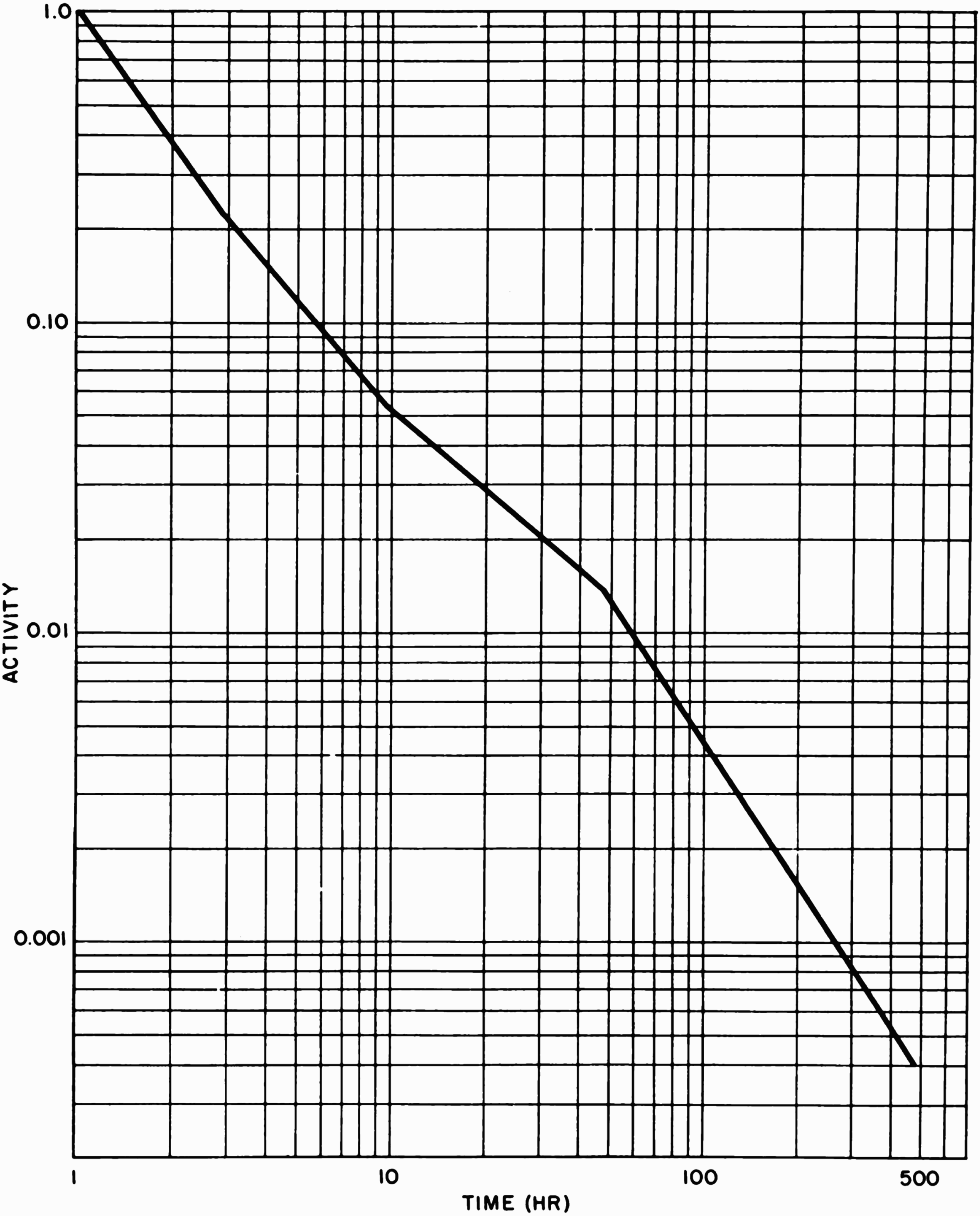


Fig. 5.3 Composite Gamma Ionization Decay Curve

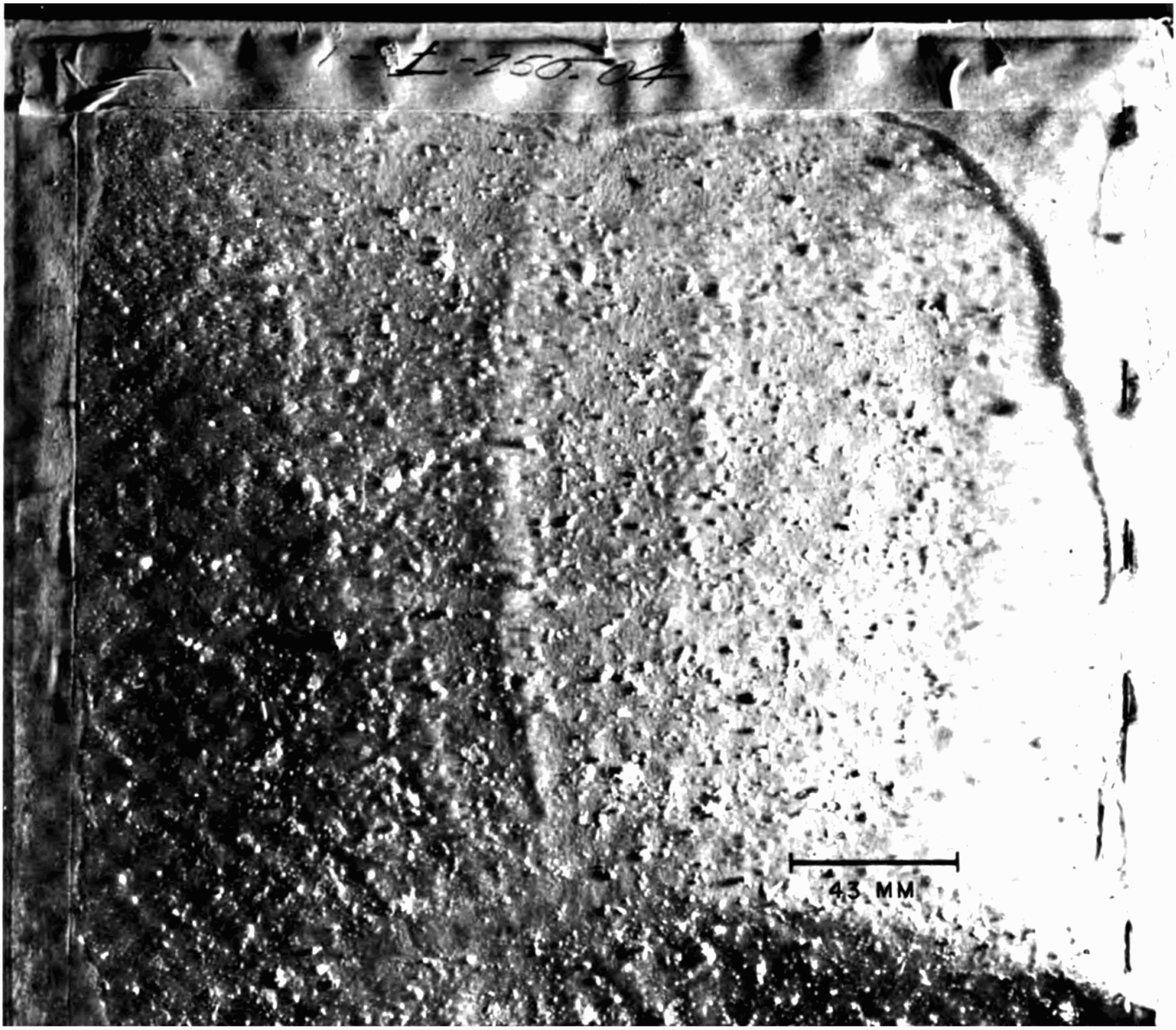


Fig. 5.10 Shot 1, Fallout Particulate, Station 250.04

This is a raft downwind in Bikini Lagoon, which received a land equivalent of 113 R/hr (1 hour reference gamma dose rate), according to Figures 2.2 and 6.1. Land equivalent dose rates were 7 times the raft dose rate in the lagoon.

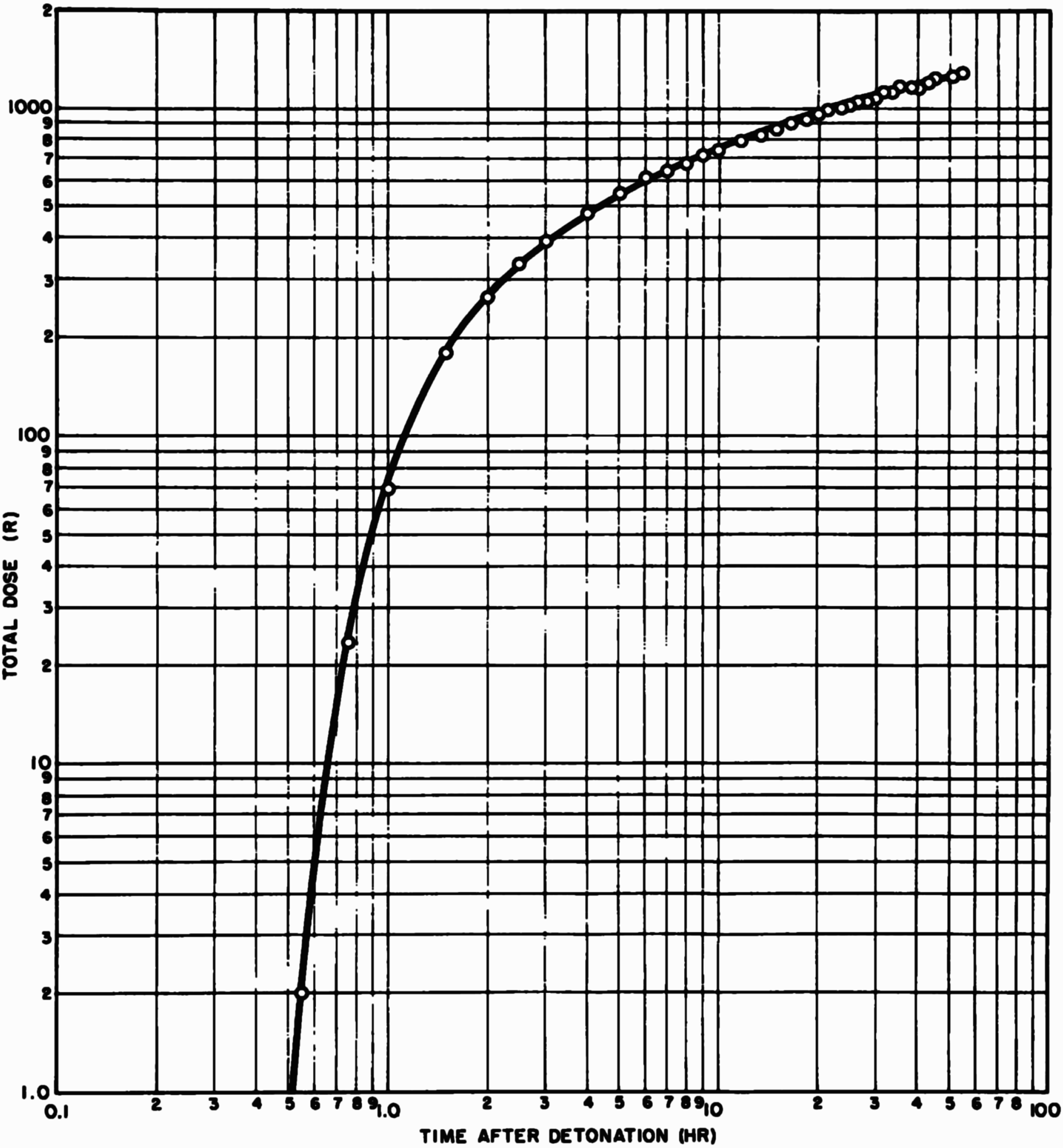
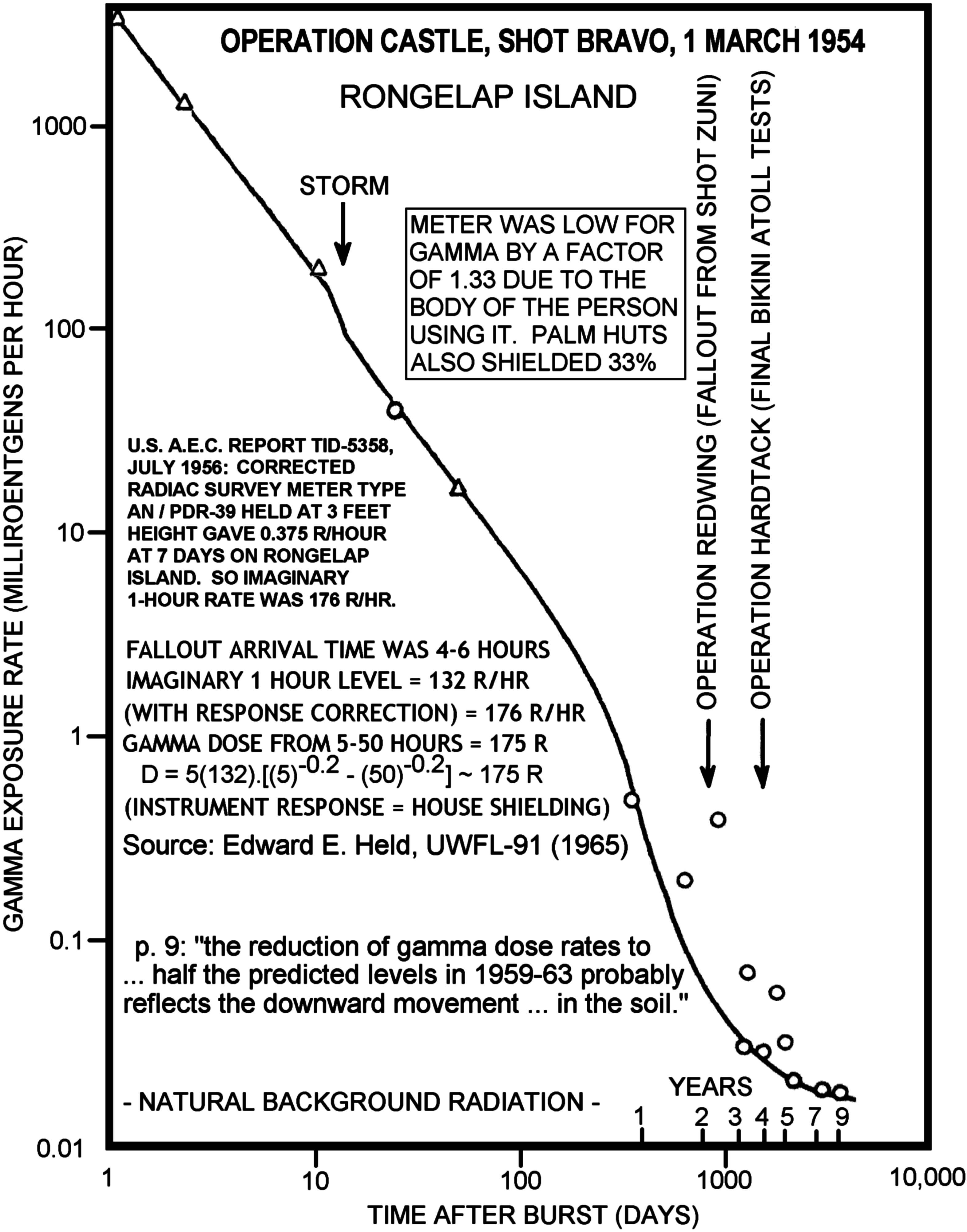


Fig. 5.11 Shot 1, Integrated Gamma Dose, Station 251.03

Bikini (How) Island in Bikini Atoll, which received a land equivalent of about 725 R/hr gamma at 1 hour reference time, according to Figures 2.2 and 6.1.



OPERATION CASTLE, SHOT BRAVO, 1 MARCH 1954
RONGELAP ISLAND
STORM
METER WAS LOW FOR GAMMA BY A FACTOR OF 1.33 DUE TO THE BODY OF THE PERSON USING IT. PALM HUTS ALSO SHIELDED 33%
OPERATION REDWING (FALLOUT FROM SHOT ZUNI)
OPERATION HARDTACK (FINAL BIKINI ATOLL TESTS)
U.S. A.E.C. REPORT TID-5358, JULY 1956: CORRECTED RADIAC SURVEY METER TYPE AN / PDR-39 HELD AT 3 FEET HEIGHT GAVE 0.375 R/HOUR AT 7 DAYS ON RONGELAP ISLAND. SO IMAGINARY 1-HOUR RATE WAS 176 R/HR.
FALLOUT ARRIVAL TIME WAS 4-6 HOURS
IMAGINARY 1 HOUR LEVEL = 132 R/HR
(WITH RESPONSE CORRECTION) = 176 R/HR
GAMMA DOSE FROM 5-50 HOURS = 175 R
D = 5(132).[(5)^-0.2 - (50)^-0.2] ~ 175 R
(INSTRUMENT RESPONSE = HOUSE SHIELDING)
Source: Edward E. Held, UWFL-91 (1965)
p. 9: "the reduction of gamma dose rates to ... half the predicted levels in 1959-63 probably reflects the downward movement ... in the soil."
- NATURAL BACKGROUND RADIATION -
YEARS
1 2 3 4 5 7 9
GAMMA EXPOSURE RATE (MILLIROENTGENS PER HOUR)
1000
100
10
1
0.1
0.01
1
10
100
1000
10,000
TIME AFTER BURST (DAYS)

[redacted]

UNCLASSIFIED

SANITIZED VERSION

TECHNICAL ANALYSIS REPORT - AFSWP NO. 507-SAN

RADIOACTIVE FALL-OUT HAZARDS FROM SURFACE BURSTS OF

VERY HIGH YIELD NUCLEAR WEAPONS, Sanitized Version

by

D. C. Borg
L. D. Gates
T. A. Gibson, Jr.
R. W. Paine, Jr.

WEAPONS EFFECTS DIVISION

This Armed Forces Special Weapons Project Technical Analysis Report is a staff study prepared for the Chief, AFSWP on a subject of military interest. The conclusions may be modified as new data become available.

MAY 1954

HEADQUARTERS, ARMED FORCES SPECIAL WEAPONS PROJECT
WASHINGTON 13, D. C.

[redacted]

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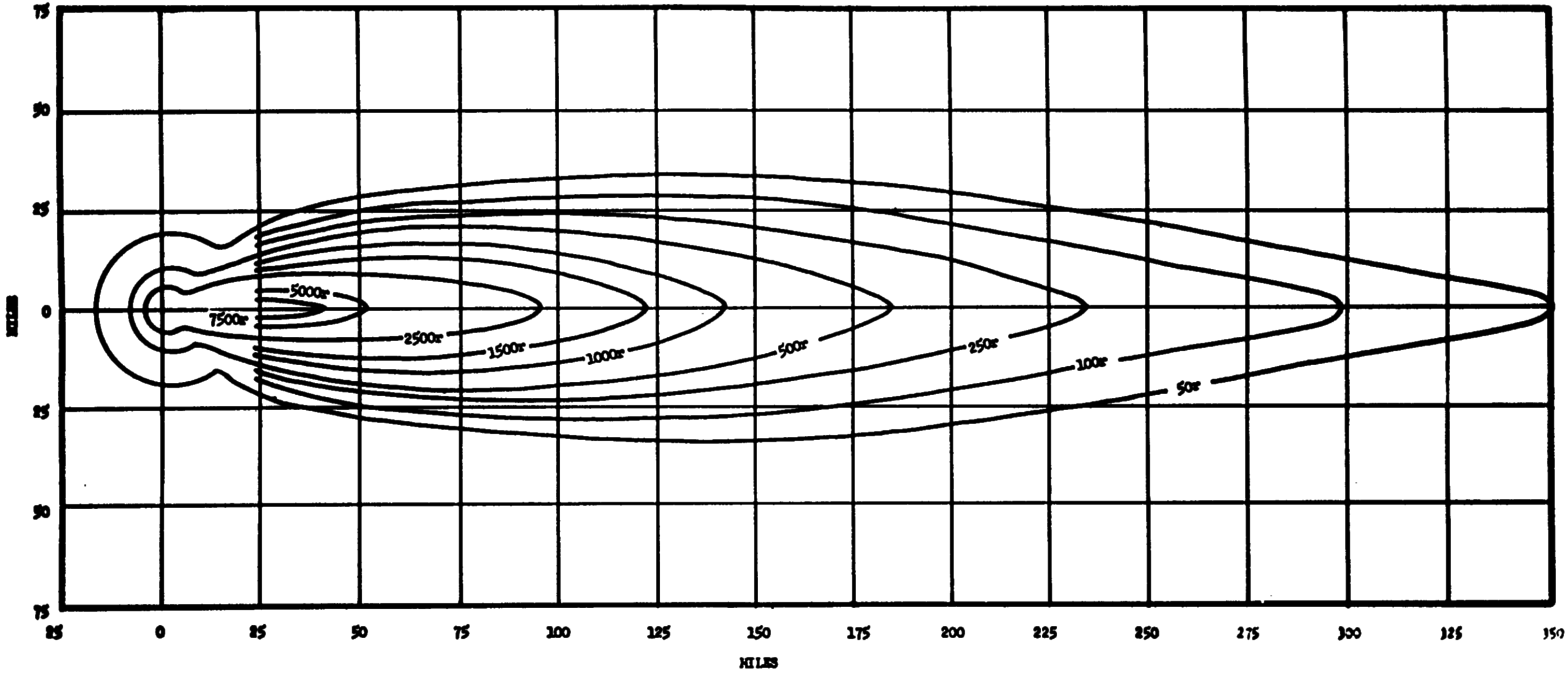
Fig. A TOTAL DOSE FROM TIME OF FALL OUT TO H+50

Idealized Fall-out Contours for a 15 MT Land-surface Burst with a 15 Knot Effective Wind



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The shielding afforded by an ordinary frame house may effectively reduce the size of the hazard areas by a factor of about two, and a basement shelter by a factor of ten or more. Virtually complete protection against the lethal effects of radioactive fall-out can be obtained if personnel have protection equal to or better than that afforded by a simple underground shelter with at least three feet of earth cover, and if they are evacuated after a week or ten days in such a shelter.

One may draw the following conclusions from this analysis:

a. Very large areas, of the order of 5,000 square miles or more, are likely to be contaminated by the detonation of a 15 megaton yield weapon on land surface, in such intensities as to be hazardous to human life.

b. The fact that a large percentage of the radiologically hazardous area will lie outside the range of destructive bomb effects for normal wind conditions, extending up to several hundred miles downwind, makes the radiological fall-out hazard a primary anti-personnel effect.

c. Accurate pre-shot prediction of the location of the hazardous area with respect to the burst point is virtually impossible without extensive wind data at altitudes up to about 100,000 feet, owing to the sensitive wind-dependence of the distribution mechanism.

d. The fall-out contaminant can be expected to decay at such a rate that all but the most highly contaminated areas could be occupied by previously unexposed personnel on a calculated risk

basis within a few days after the contaminating event; and even these highly contaminated areas may then be entered briefly by decontamination teams.

e. Passive defense measures, intelligently applied, can drastically reduce the lethally hazardous areas. A course of action involving the seeking of optimum shelter, followed by evacuation of the contaminated area after a week or ten days, appears to offer the best chance of survival. At the distant downwind areas, as much as 5 to 10 hours after detonation time may be available to take shelter before fall-out commences.

f. Universal use of a simply constructed deep underground shelter, a subway tunnel, or the sub-basement of a large building could eliminate the lethal hazard due to external radiation from fall-out completely, if followed by evacuation from the area when ambient radiation intensities have decayed to levels which will permit this to be done safely.

g. It is of vital importance for individuals in hazardous areas to seek optimum shelter at once, since the dosage received in the first few hours after fall-out has commenced will exceed that received over the rest of a week spent in the contaminated area.

Table II

Total Isodose Contour: 500r from Fall-out to H+50 Hours

Yield (MT)	15	1	10	60	* 60
Downwind extent (mi)	180	52	152	340	(307)
Crosswind axis (mi)	40	12	34	70	
GZ circle radius (mi)	11.5	3.85	9.7	21	
GZ circle displacement (mi)	3.5	1.2	3	5.75	
Area (mi^2)	5400	470	3880	17,900	(16,250)
Area of true ellipse (mi^2)	(5650)	(491)	(4055)	(18,700)	

* Using Part D, Chapter II.

The Effects of

Nuclear Weapons

SAMUEL GLASSTONE
Editor

Revised Edition
Reprinted February 1964

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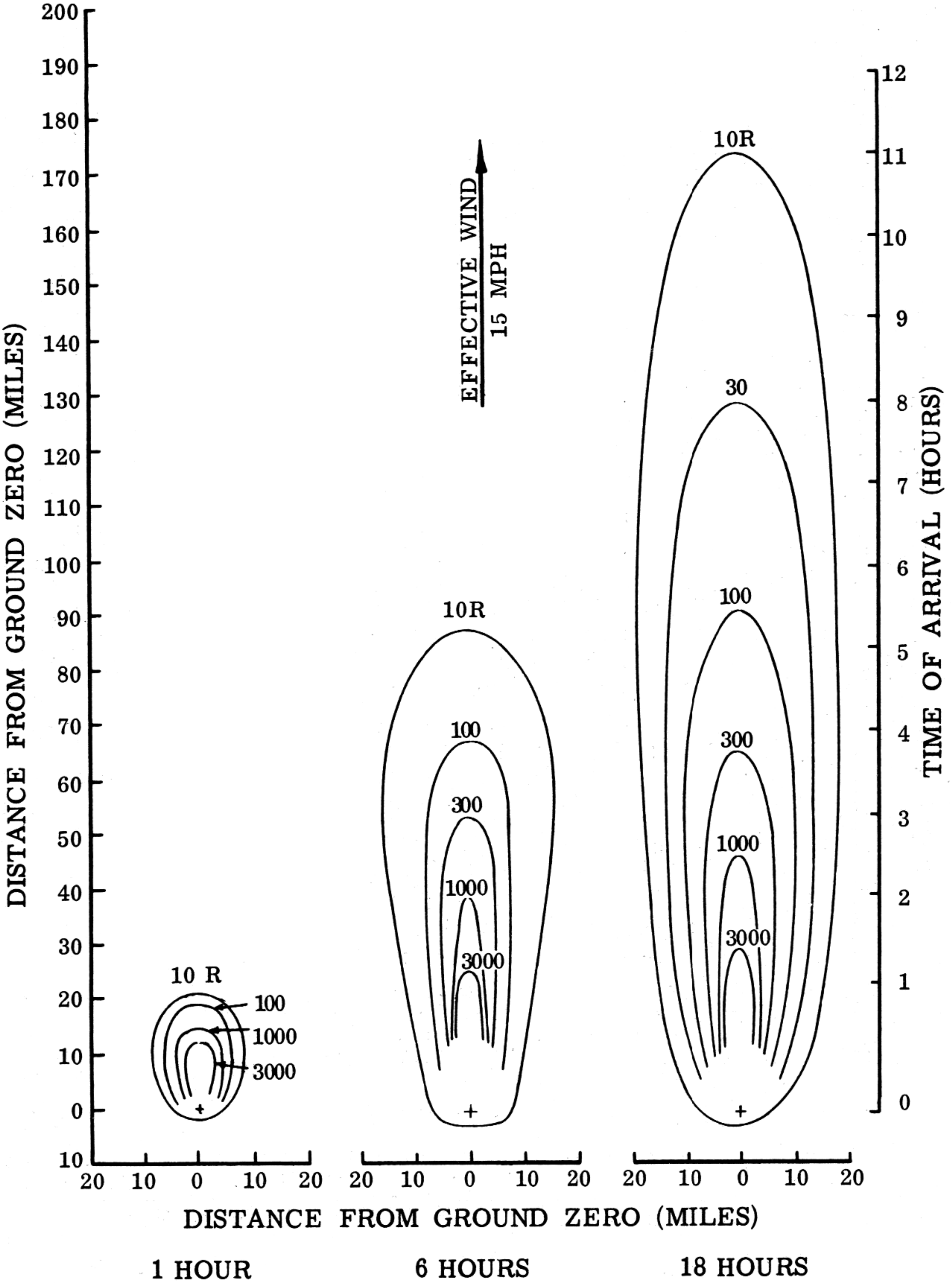


Figure 9.67b. Total-dose contours from early fallout at 1, 6, and 18 hours after surface burst with 1-megaton fission yield (15 mph effective wind speed).

11.149 Valuable information concerning the development and healing of beta burns has been obtained from observations of the Marshall Islanders who were exposed to fallout in March 1954. Within about 5 hours of the burst, radioactive material commenced to fall on some of the islands. Although the fallout was observed as a white powder, consisting largely of particles of lime (calcium oxide) resulting from the decomposition of coral (calcium carbonate) by heat, the island inhabitants did not realize its significance. Because the weather was hot and damp, the Marshallese remained outdoors; their bodies were moist and they wore relatively little clothing. As a result, appreciable amounts of fission products fell upon the hair and skin and remained there for a considerable time. Moreover, since the islanders, as a rule, did not wear shoes, their bare feet were continually subjected to contamination from fallout on the ground.

11.150 During the first 24 to 48 hours, a number of individuals in the more highly contaminated groups experienced itching and a burning sensation of the skin. These symptoms were less marked among those who were less contaminated with early fallout. Within a day or two all skin symptoms subsided and disappeared, but after the lapse of about 2 to 3 weeks, epilation and skin lesions were apparent on the areas of the body which had been contaminated by fallout particles. There was apparently no erythema, either in the early stages (primary) or later (secondary), as might have been expected, but this may have been obscured by the natural coloration of the skin.

11.151 The first evidence of skin damage was increased pigmentation, in the form of dark colored patches and raised areas (macules, papules, and raised plaques). These lesions developed on the exposed parts of the body not protected by clothing, and occurred usually in the following order: scalp (with epilation), neck, shoulders, depressions in the forearm, feet, limbs, and trunk. Epilation and lesions of the scalp, neck, and foot were most frequently observed (Figs. 11.151 a and b).

11.152 In addition, a bluish-brown pigmentation of the fingernails was very common among the Marshallese and also among American Negroes. The phenomenon appears to be a radiation response peculiar to the dark-skinned races, since it was not apparent in any of the white Americans who were exposed at the same time. The nail pigmentation occurred in a number of individuals who did not have skin lesions. It is probable that this was caused by gamma rays, rather than by beta particles, as the same effect has been observed in dark-skinned patients undergoing X-ray treatment in clinical practice.

11.153 Most of the lesions were superficial without blistering. Microscopic examination at 3 to 6 weeks showed that the damage

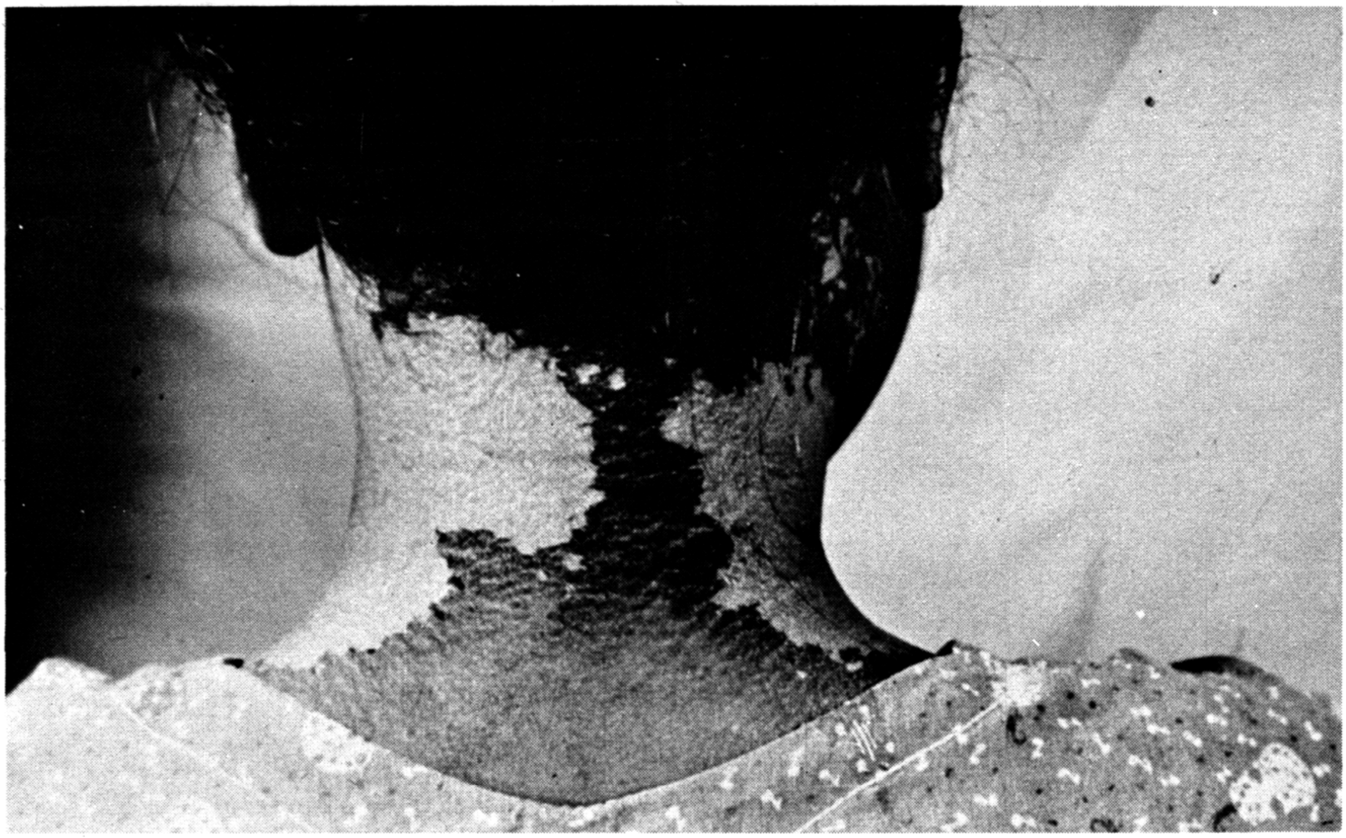
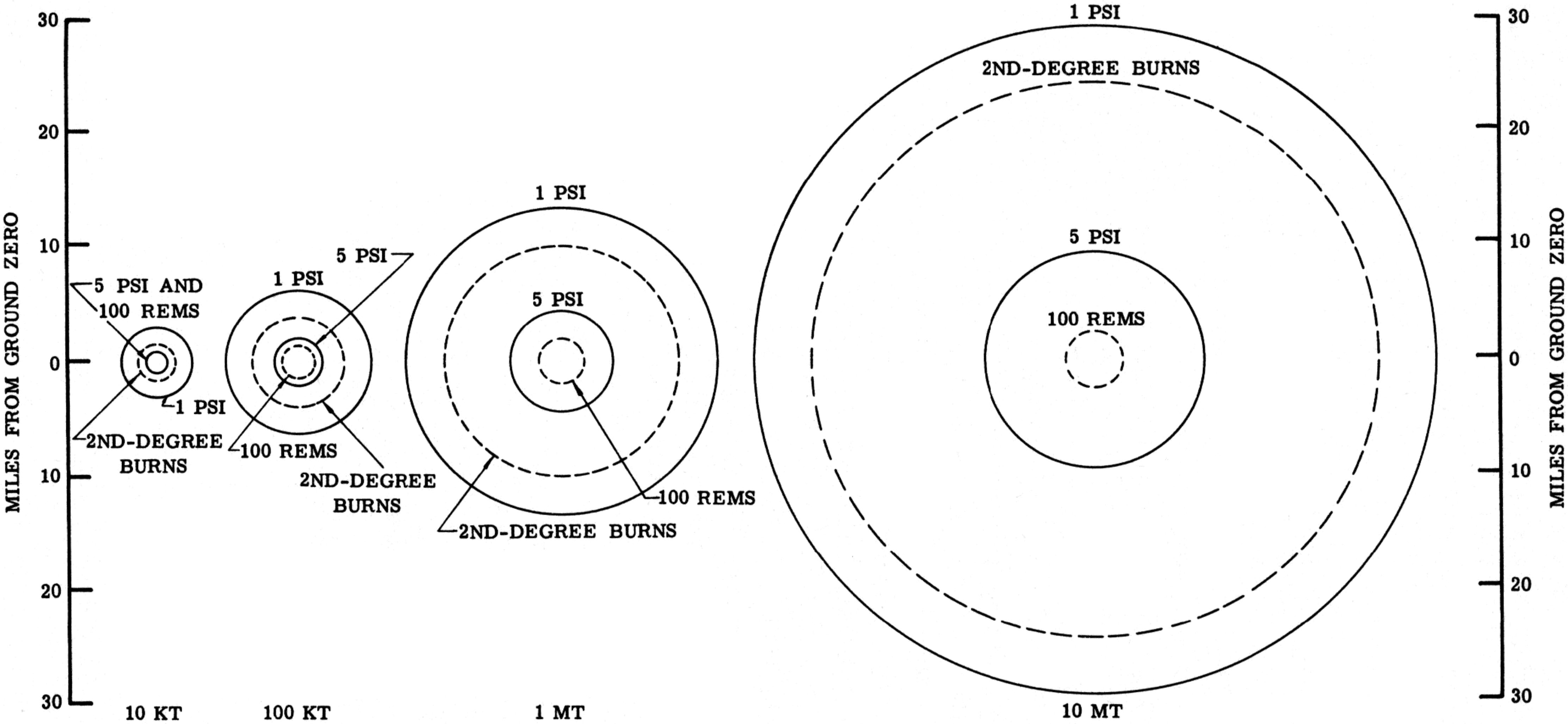


Figure 11.151a. Beta burn on neck 1 month after exposure.

was most marked in the outer layers of the skin (epidermis), whereas damage to the deeper tissue was much less severe. This is consistent with the short range of beta particles in animal tissue. After formation of dry scab, the lesions healed rapidly leaving a central depigmented area, surrounded by an irregular zone of increased pigmentation. Normal pigmentation gradually spread outward in the course of a few weeks.

11.154 Individuals who had been more highly contaminated developed deeper lesions, usually on the feet or neck, accompanied by mild burning, itching, and pain. These lesions were wet, weeping, and ulcerated, becoming covered by a hard, dry scab; however, the majority healed readily with the regular treatment generally employed for other skin lesions not connected with radiation. Abnormal pigmentation effects persisted for some time, and in several cases about a year elapsed before the normal (darkish) skin coloration was restored (Figs. 11.154 a and b).

11.155 Regrowth of hair, of the usual color (in contrast to the skin pigmentation) and texture, began about 9 weeks after contamination and was complete in 6 months. By the same time, nail discoloration had grown out in all but a few individuals. Seven years later, there were only 10 cases which continued to show any effects of beta burns, and there was no evidence of malignant changes.



Idealized ranges for effects of air burst with the heights of burst optimized to give the maximum range for each effect

Effective Protection Areas

12.11 In Japan, where little evasive action was taken, the survival probability depended upon whether the individual was outdoors or inside a building and, in the latter case, upon the type of structure. At distances between 0.3 and 0.4 mile (530 and 700 yards) from ground zero in Hiroshima the average survival rate, for at least 20 days after the nuclear explosion, was less than 20 percent. Yet in two reinforced-concrete office buildings, at these distances, almost 90 percent of the nearly 800 occupants survived more than 20 days, although some died later from radiation injury. Furthermore, of approximately 3,000 school students who were in the open and unshielded within a mile of ground zero at Hiroshima, about 90 percent were dead or missing after the explosion. But of nearly 5,000 students in the same zone who were shielded in one way or another, only 26 percent were fatalities. These facts bring out clearly the greatly improved chances of survival from a nuclear explosion that could result from the adoption of suitable warning and protective measures.

12.12 As a rough guide, the inner range at which protection in conventional structures could be achieved may be supposed to be that where the overpressure is 5 pounds per square inch and the outer range, beyond which casualties will be small *for an air burst*, is at 1 pound per square inch (or the limit for second-degree burns). As seen above, survival in Hiroshima was possible in buildings at such distances that the overpressure in the open was 15 to 20 pounds per square inch. The somewhat arbitrary choice of an overpressure of 5 pounds per square inch, which was experienced at a little over a mile from ground zero in Japan, is thus very conservative. In any case, it is evident from the circles in Fig. 12.08 that the area over which protection could be effective in saving lives is roughly eight to ten times as great as that in which the chances of survival are small.

Distance (miles)	Explosion yield 1 KT	10 KT	100 KT	1 MT	10 MT
	(Time in seconds)				
1	4. 3	3. 6	3. 7	2. 5	1. 5
2	>9	8. 1	7. 4	6. 5	5. 0
3	--------	>13	12	11	9. 5
5	--------	--------	21	20	16
7	--------	--------	>30	28	26
10	--------	--------	--------	42	37
20	--------	--------	--------	>90	83
30	--------	--------	--------	--------	>130

12.30 It is seen that at 10 miles from a 10-megaton air burst, which is within the area where protection against blast could be effective, some 37 seconds would elapse before arrival of the blast wave. If prompt action is taken, a person in a building could reach a position of the type indicated above. In the open, some protection against the blast may be obtained by falling prone, and remaining in that position until the wave has passed. In the prone position, with the head directly toward or directly away from the explosion, the area of the body exposed to the onrushing blast wave is relatively small and the danger of displacement is thereby decreased (cf. § 11.38).

12.35. The major part of the thermal radiation travels in straight lines, and so any opaque object interposed between the fireball and the exposed skin will give some protection. This is true even if the object is subsequently destroyed by the blast, since the main thermal radiation pulse is over before the arrival of the blast wave.

12.36 At the first indication of a nuclear explosion, by a sudden increase in the general illumination, a person inside a building should immediately fall prone, as described in § 12.30, and, if possible, crawl behind or beneath a table or desk or to a planned vantage point. Even if this action is not taken soon enough to reduce the thermal radiation exposure greatly, it will minimize the displacement effect of the blast wave and provide a partial shield against splintered glass and other flying debris. An individual caught in the open should fall prone to the ground in the same way, while making an effort to shade exposed parts of the body. Getting behind a tree, building, fence, ditch, bank, or any structure which prevents a direct line of sight between the person and the fireball, if possible, will give a major degree of protection. If no substantial object is at hand, the clothed parts of the body should be used to shield parts which are exposed. There will still be some hazard from scattered thermal radiation, especially from high-yield weapons at long range, but the decrease in the direct radiation will be substantial.

12.55 A fallout shelter of the kind referred to in § 12.53 will provide a protection factor of about 200 from the residual radioactivity; in other words, the dose rate in the shelter will be only ½ percent of that measured outside at a height of 3 feet above the ground. Where a shelter is not available, a similar protection factor from radiation can be obtained in the following manner in a small area of the basement of a two-story house. A sturdy table is placed in a corner adjacent to an unexposed outer wall and covered with 10 to 12 inches of soil, sandbags, solid concrete block, etc., according to what is available. If there are no heavy partitions or walls near the corner of the basement chosen, a layer of sandbags or concrete blocks should be stacked along the walls up to the height of the material on top of the table. Within the area under the table, there will be a protective factor of at least 100 from fallout radiation. The disadvantage of this type of protection is that it is unlikely that stocks of food and water would be available within the shelter, so that it could not be occupied continuously for an extended period, as could the more permanent type outlined previously. In almost any house with a buried basement, having uniformly thick exterior walls, a protection factor of 20 to 40 is possible. The maximum protection can be obtained near the floor and in the corners of the basement adjacent to an unexposed outer wall.

12.56 Before leaving a shelter, either temporarily or permanently, it is highly desirable that the radiation dose rate, both in the immediate area of the shelter and in the surrounding vicinity, be known. Marked variations in fallout patterns have been observed in weapons tests, with unexpected areas (hot spots) of exceptionally high activity. Hence, it is not sufficient to know merely that a nearby location is relatively safe. Communications equipment, e.g., battery-powered radios, and radiation measuring instruments should be in shelters. Otherwise it will not be possible to obtain information on radiation dose rates in the locality and in the immediate vicinity of the shelter, particularly at early times when high radiation levels will prevent radiation monitors from moving safely and freely about the community. As a rough rule-of-thumb, it may be stated that for every sevenfold increase in time, the radiation level will decrease by a factor of 10, provided the fallout is complete. For example, the radiation level at the end of 7 days will have fallen to roughly one-tenth of that at the end of 1 day. At the end of 49 days, it will have decreased by a factor of 100, etc.[3]

12.57 It is appropriate to mention here that whether or not fallout is visible to the eye, its measurement requires the use of suitable

[3] The rule is applicable to any unit of time; thus at 7 hours the residual radiation level will be one-tenth of that at 1 hour, at 14 hours it will be one-tenth of that at 2 hours, and so on, provided the fallout is complete at both times.

instruments sensitive to nuclear radiations. Some, although perhaps not all, of the fallout in the Marshall Islands, after the test explosion of March 1, 1954 (§ 9.100 *et seq.*), could be seen as a white powder or dust. This was due, partly at least, to the light color of the calcium oxide or carbonate of which the particles were mainly composed. It is probable that whenever there is sufficient fallout to constitute a hazard, the dust will be visible. Nevertheless, continuous monitoring with instruments for radioactive contamination would appear to be essential in all areas in the vicinity of the burst.

RADIOLOGICAL SURVEYS

12.58 As soon after a nuclear explosion as conditions permit, radiological monitoring surveys will have to be initiated for the purpose of developing information on the extent and levels of the contamination. At early times in heavily contaminated areas, where dose rates will be very high, only the most limited amount of monitoring can be accomplished by individuals with hand-carried instruments. In these circumstances, some kind of remote radiation monitoring equipment may be necessary. This will permit the monitor to remain within the shelter while taking readings of the dose rate outside.

12.59 The most rapid method for obtaining radiation levels in a large area is by aerial survey. Because of their long range in air, gamma rays can be detected by sensitive instruments at a height of a few thousand feet. Low-flying airplanes or helicopters, carrying suitable radiation instruments for measuring dose rates, can survey large areas unimpeded by damage on the surface and by impassable streets and roads. Moreover, by making initial flights at an altitude of 1,600 feet or so, the dose rates are only about 1 percent of those on the ground, so that the hazard to the monitor is decreased accordingly.

12.60 The dose rates measured at an altitude must be multipled by an appropriate factor to give the approximate dose rates near the ground. This factor will depend primarily on the height above the ground and nature of the terrain. In the absence of more specific information, the data in Fig. 9.181 may be used to estimate the attenuation factor at a known altitude with reference to that at a height 3 feet above the ground.

12.61 The aerial survey is important because it can be made readily and can provide information which might be impossible to obtain in any other way at the time of interest. Nevertheless, such a survey can serve only as a rough guide and should be made only after all the early fallout is out of the air and on the ground.

12.78 In the event that shelters are not available, certain evasive actions may prove helpful at distances where the immediate effects are least severe. By instantly falling prone and covering exposed portions of the body or getting behind opaque objects, much of the thermal radiation may be avoided, especially in the case of large-yield weapons. Under no circumstances should an individual look in the direction of the fireball. Staying behind thick walls or lying in a deep ditch may help to avoid initial nuclear radiation. All of the above actions will also help to decrease the possible danger from the blast wave. Moreover, persons should avoid areas which have frangible materials, such as window glass, plaster, etc., which may become flying debris by the action of the blast.

12.79 After the immediate effects of the nuclear explosion are over, certain acts are required to minimize the hazards of the early fallout and from the fires which may result from thermal radiation and secondary blast effects. First, if small fires can be quickly extinguished, extensive conflagrations may be prevented. This must be accomplished before the arrival of the fallout or in areas of low radioactivity levels. Some protection from the fallout may be secured in the basements of buildings or in a quickly constructed shelter, such as is described in § 12.55. It is important to keep from coming into physical contact with the fallout particles, and to prevent contamination of food and water sources. Monitoring equipment should be used to determine areas which have safe radiation levels and decontamination efforts can proceed to recover necessary equipment, buildings, and areas.

Conclusion

12.80 Much of the discussion presented in earlier sections of this chapter have been based, for simplicity, on the effects of a single weapon. It must not be overlooked that in a nuclear attack some areas may be subjected to several bursts. The basic principles of protection would remain unchanged, but protective action against *all* the effects of a nuclear explosion—blast, thermal radiation, initial nuclear radiation, and fallout—would become even more important. There is a good possibility that many people would survive a nuclear attack and this possibility would be greatly enhanced by utilizing the principles of protection in preattack preparations and planning, in taking evasive action at the time of an attack, and in determining what should be done in the recovery phase after the attack.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

88 Large buildings with a number of storeys, especially if they are of heavy construction, provide much better protection than small single-storey structures (see Figure 4). Houses in terraces likewise provide much better protection than isolated houses because of the shielding effect of neighbouring houses.

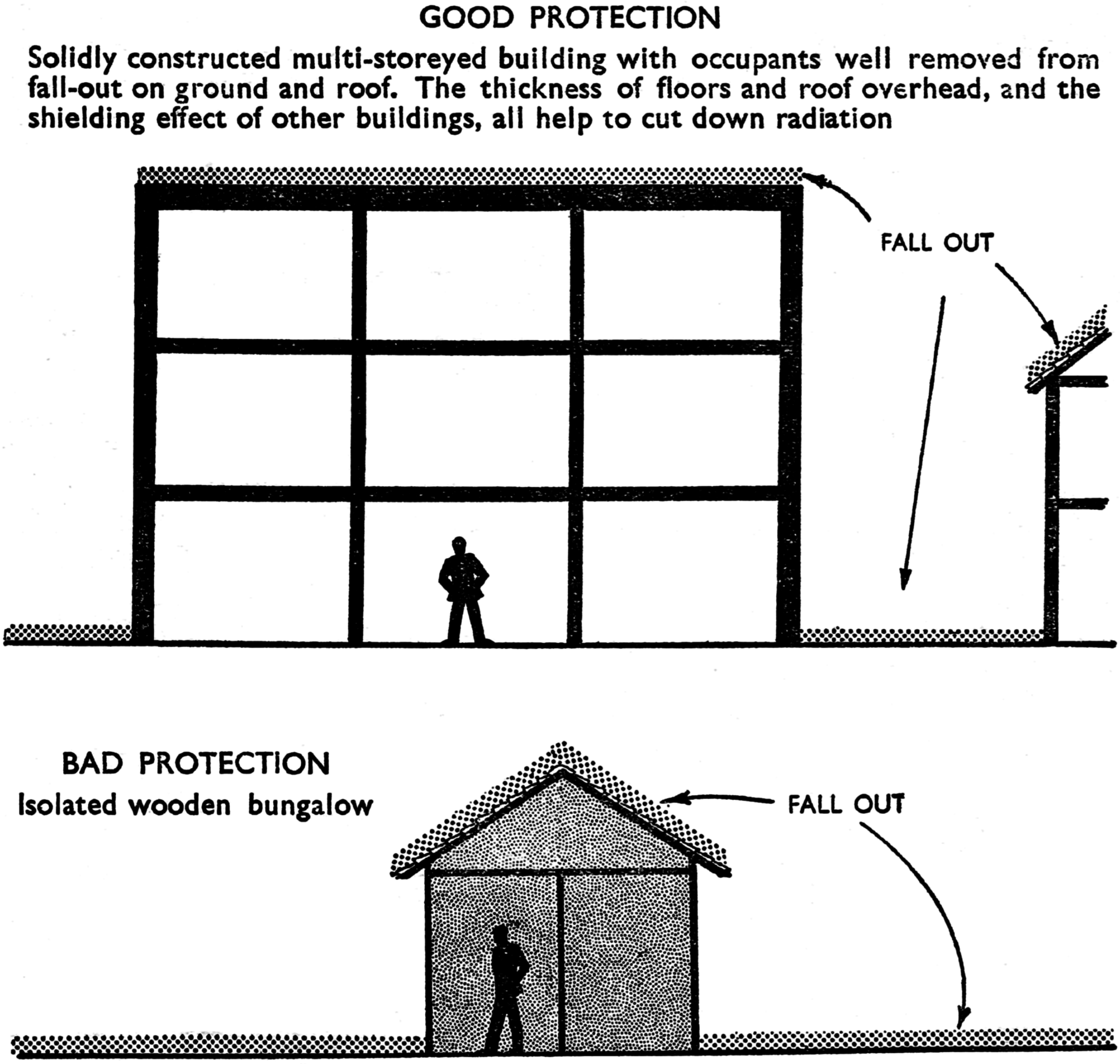


FIGURE 4

Examples of good and bad protection afforded by buildings against fall-out.

89 It is estimated that the protection factor (the factor by which the outside dose has to be divided to get the inside dose) of a ground floor room in a two-storey house ranges from 10 to about 50, depending on wall thickness and the shielding afforded by neighbouring buildings. The corresponding figures for bungalows are about 10–20, and for three-storey houses about 15–100. An average two-storey brick house in a built-up area gives a factor of 40, but basements, where the radiation from outside the house is attenuated by a very great thickness of earth, have protection factors ranging up to 200–300. A slit trench with even a light cover of boards or corrugated iron without earth overhead gives a factor of 7, and if 1 ft. of earth cover is added the

factor rises to 100. If the trench can be covered with 2 or 3 feet of earth then a factor of more than 200–300 can be obtained (see Figure 5).

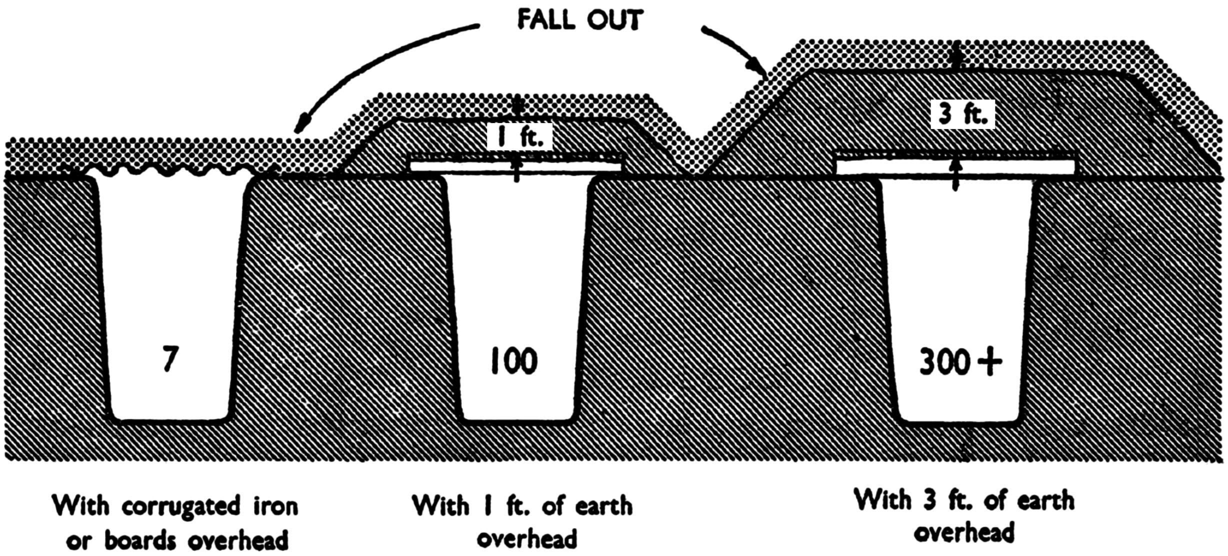


FIGURE 5
Protection factors in slit trenches (the factor by which the outside dose is divided to get the inside dose).

Choosing a refuge room

90 In choosing a refuge room in a house one would select a room with a minimum of outside walls and make every effort to improve the protection of such outside walls as there were. In particular the windows would have to be blocked up, e.g. with sandbags. Where possible, boxes of earth could be placed round an outside wall to provide additional protection, and heavy furniture (pianos, bookcases etc.) along the inside of the wall would also help. A cellar would be ideal. Where the ground floor of the house consists of boards and timber joists carried on sleeper walls it may be possible to combine the high protection of the slit trench with some of the comforts of the refuge room by constructing a trench under the floor.
Once a trap door had been cut in the floor boards and joists and the trench had been dug, there would be no further interference with the peace-time use of the room.

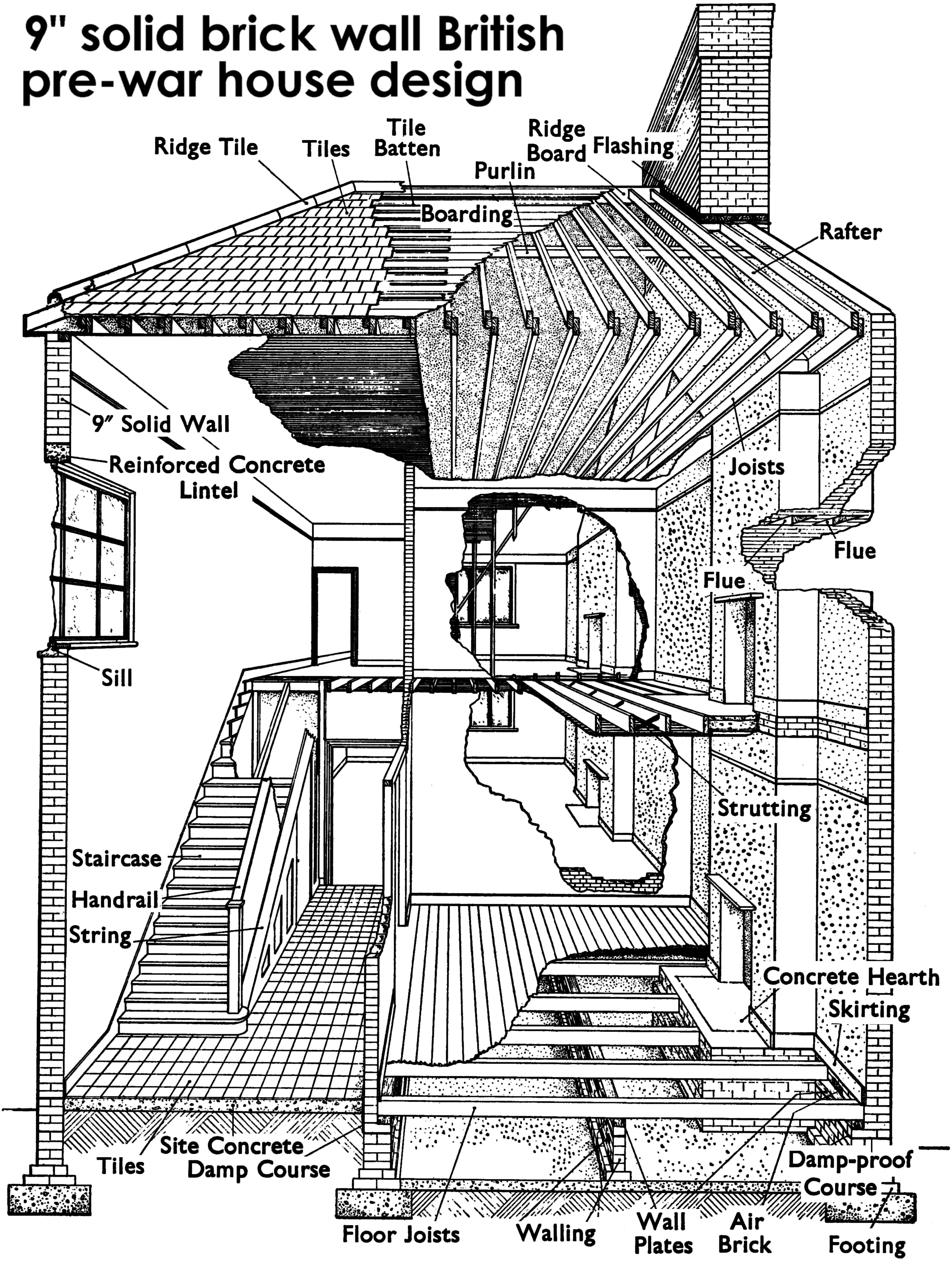
Estimated under-cover doses in the fall-out area

91 Taking an average protective factor of 40 for a two-storey house in a built-up area, the doses accumulated in 36 hours for the ranges referred to in the U.S. Atomic Energy Commission Report (paragraph 84) would have been:—

190 miles downwind	$7\frac{1}{2}$r	15 Megatons
160 ,, ,,	$12\frac{1}{2}$r	Bravo 1954
140 ,, ,,	20r	

which are all well below the lowest figure of 25r referred to in Table 1. At closer ranges along the axis of the fall-out, the doses accumulated in 36 hours would have been much higher, but over most of the contaminated area—with this standard of protection—the majority of those affected would have been saved from death, and even from sickness, by taking cover continuously for the first 36 hours.

9" solid brick wall British pre-war house design



5. Radiation sickness

Assume dose incurred in a single shift (3–4 hours) by the "average" man, over the whole body:—

25 roentgens	—No obvious harm.
100 ,,	—Some nausea and vomiting.
500 ,,	—Lethal to about 50 per cent. people (death up to 6 weeks later).
800 ,, or more	—Lethal to all (death up to 6 weeks later).

Note: If dose spread uniformly over 2–3 days, then 60 roentgens could be incurred with no more effect than 25 roentgens in a single exposure of 3–4 hours.

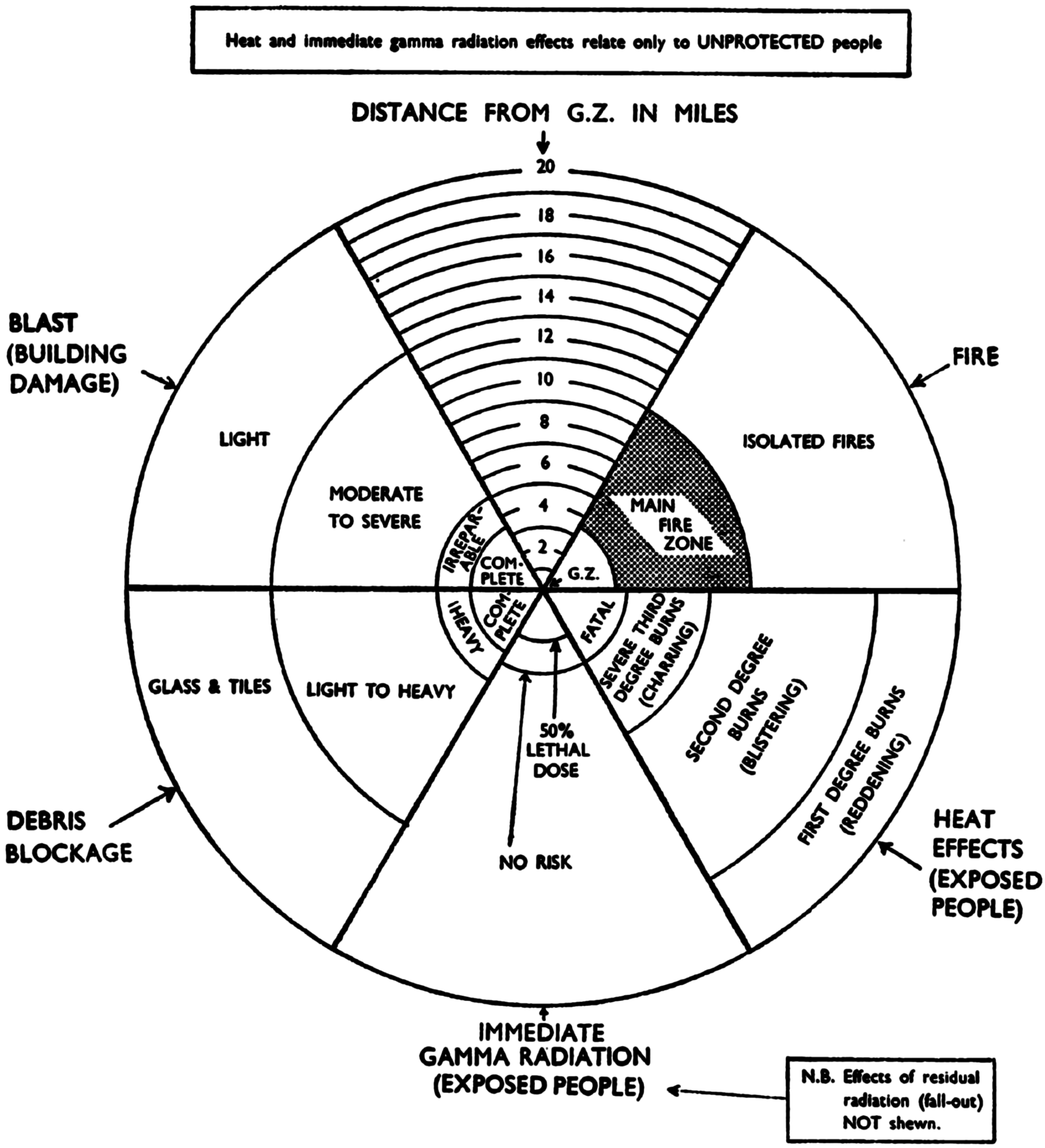


FIGURE 11

Combined effects (excluding residual radioactivity) from a 10 megaton ground burst bomb. Heat and immediate gamma radiation effects relate only to UNPROTECTED people.

A Fallout Forecasting Technique With Results Obtained at the Eniwetok Proving Ground

E. A. Schuert, USNRDL TR–139, United States Naval Radiological Defense Laboratory, San Francisco, Calif.

Administrative Information

The work described herein is a part of the research sponsored by BuShips and the United States Army and locally designated as program 2, problem 3, phase 3. Its technical objective is AW–7 and it is described on RDB card NS 081–001.

Summary

The problem: A fallout forecasting technique is needed to qualitatively describe the fallout hazard resulting from nuclear detonations. This technique should have such flexibility that its employment is valid for field use.

Findings: A summary of the latest experimental and theoretical considerations has resulted in the development of a technique whose complexity is dependent on the required accuracy of the results desired. This technique has been satisfactorily tested at the Eniwetok Proving Grounds for land surface and water surface bursts.

Particle size distribution in source model

All particle sizes were assumed at all elevations within the cloud except the lower two-thirds of the stem. However, to obtain agreement with past fallout measurements and with the optical diameter of the mushroom, it was necessary to fractionate the particle size distribution radially within the cloud. Otherwise, the computed fallout area about ground zero would be too large. The fractionation was specified as follows: particles of 1,000 microns in diameter and larger were restricted to the inner 10 percent of the mushroom radius or approximately the stem radius; those from 500 to 1,000 microns in diameter were limited to the inner 50 percent of the cloud radius. Since the relation of activity to particle size is some function of the particle diameter this fractionation tends to concentrate the activity about the axis of symmetry of the cloud.

Falling speeds **(feet/hour)**

J. M. Dallavalle, Mircomeritics, Pittman Publishing Corp., 1948.

Altitude	75 μ	100 μ	200 μ	350 μ	Altitude	75 μ	100 μ	200 μ	350 μ
0	3,060	5,040	11,700	21,600	65	4,190	7,480	26,100	51,100
5	3,120	5,240	12,300	22,900	70	4,110	7,320	27,600	55,200
10	3,200	5,480	12,900	24,100	75	4,010	7,150	28,100	59,700
15	3,270	5,750	13,700	25,500	80	3,910	6,960	27,800	61,900
20	3,360	5,980	14,400	27,100	85	3,800	6,770	27,100	67,800
25	3,470	6,160	15,300	28,800	90	3,720	6,640	26,500	71,300
30	3,570	6,380	16,300	30,800	95	3,620	6,470	25,800	77,300
35	3,720	6,640	17,500	33,000	100	3,550	6,340	25,300	80,200
40	3,870	6,910	18,600	35,300	105	3,470	6,180	24,800	75,800
45	4,040	7,200	19,800	37,800	110	3,400	6,050	24,000	74,200
50	4,210	7,520	21,400	40,600	115	3,330	5,930	23,700	72,600
55	4,420	7,860	23,200	44,600	120	3,260	5,800	23,400	71,100
60	4,200	7,700	24,400	47,200					

Experimental data from past tests at Eniwetok Atoll indicated that the particles were irregular in shape and had a mean density of 2.36 g/cu cm.

Time variation of the winds aloft

In most of the observations made at the Eniwetok Proving Ground, the winds aloft were not in a steady state. Significant changes in the winds aloft were observed in as short a period as 3 hours. This variability was probably due to the fact that proper firing conditions which required winds that would deposit the fallout north of the proving ground, occurred only during an unstable synoptic situation of rather short duration.

The forecasting technique described was employed by the fallout program at the Eniwetok Proving Ground to satisfy certain project requirements. One project had three ships equipped to collect fallout and their positions had to be determined for most efficient collection; another sampled the ocean for fallout; while another made an aerial survey of the contaminated area. The navigational schedules for these latter projects were based on the forecast fallout pattern. Operations were controlled through the program control center aboard the task force command ship where the forecasts were prepared.

The meteorological data was received from the weather ship at Bikini Atoll as well as from weather stations at Rongerik Atoll and Eniwetok Atoll. Furthermore all forecasts made by the task force weather central at Eniwetok Atoll were usually available aboard the command ship by facsimile through the ships weather station.

Upper air measurements were made at Bikini, Rongerik, and Eniwetok Atolls every 3 hours starting at H—24 hour and continuing until H+24 hour for any given detonation. The frequency of observations was usually increased during the period from H—6 to H—2 hours. The altitudes reached on the wind runs were remarkably high and gave perhaps the best set of winds-aloft measurements to date. The average termination altitude was approximately 90,000 feet with many runs over 100,000 feet. Such excellent coverage of the winds aloft was a major help in the fallout forecasting.

Fallout forecasts were made every 3 hours starting at H—24 hour using the *measured* winds available at the time. This process was continued up to shot time and from then on the technique of correcting for time variation was employed every 3 hours until the fallout event was completed. It was not feasible to correct for space variation and vertical motions during this period because of lack of time and data.

Fallout plots

The fallout forecasts determined at the weapons-test operation were based entirely on measured data and quantitatively considered time variation of the wind. No space variation corrections or computed values of vertical motions were employed in their construction.

A and B were land-surface detonations, C and D were water-surface shots.

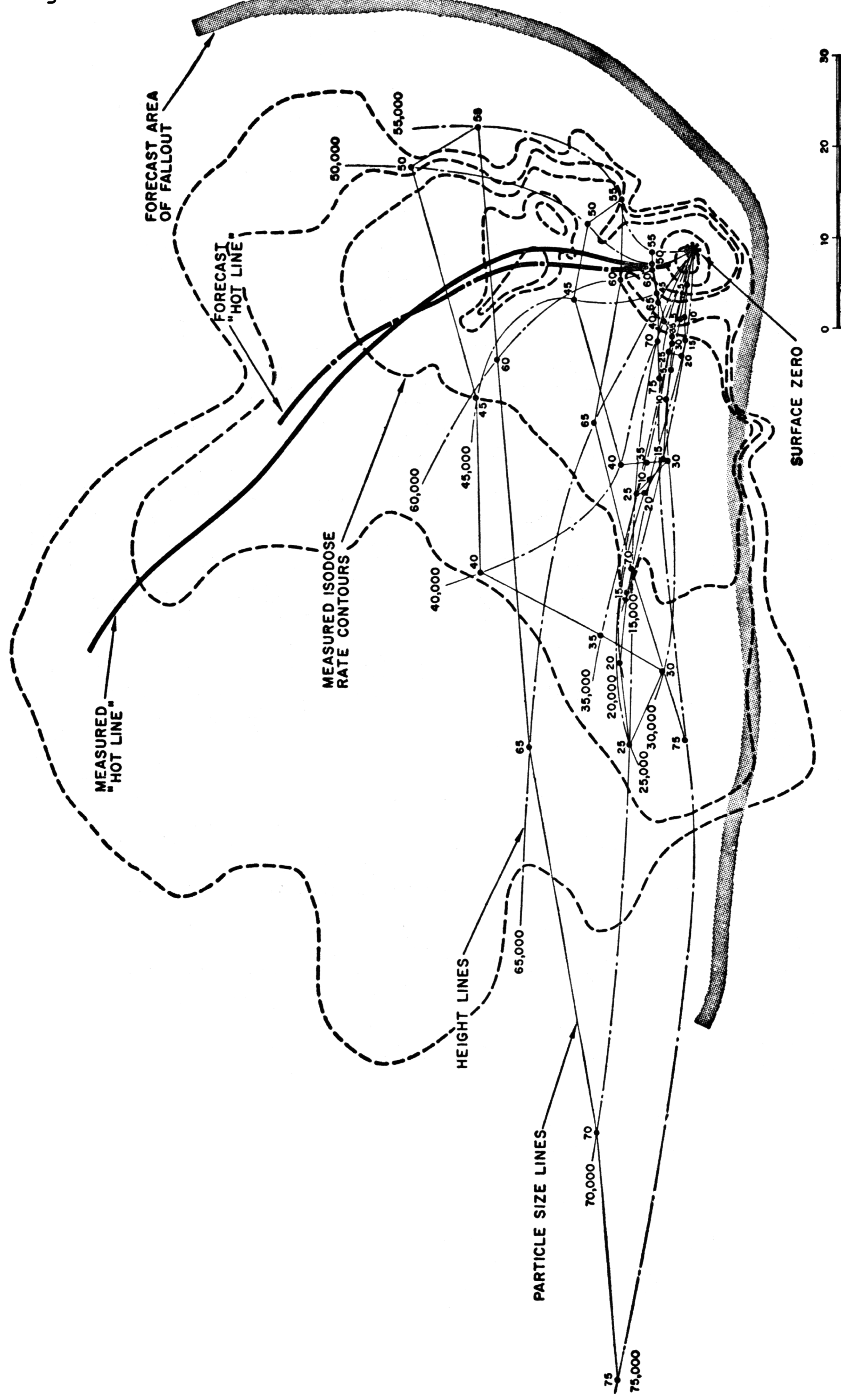
The comparison is excellent for all shots except B.

SUMMARY

The fallout forecasting technique described in this report was successfully employed for both land surface and water surface detonations at the Eniwetok Proving Ground. With known meterological data such a technique will successfully qualify the area of fallout and indicate qualitatively the relative intensity of radiation.

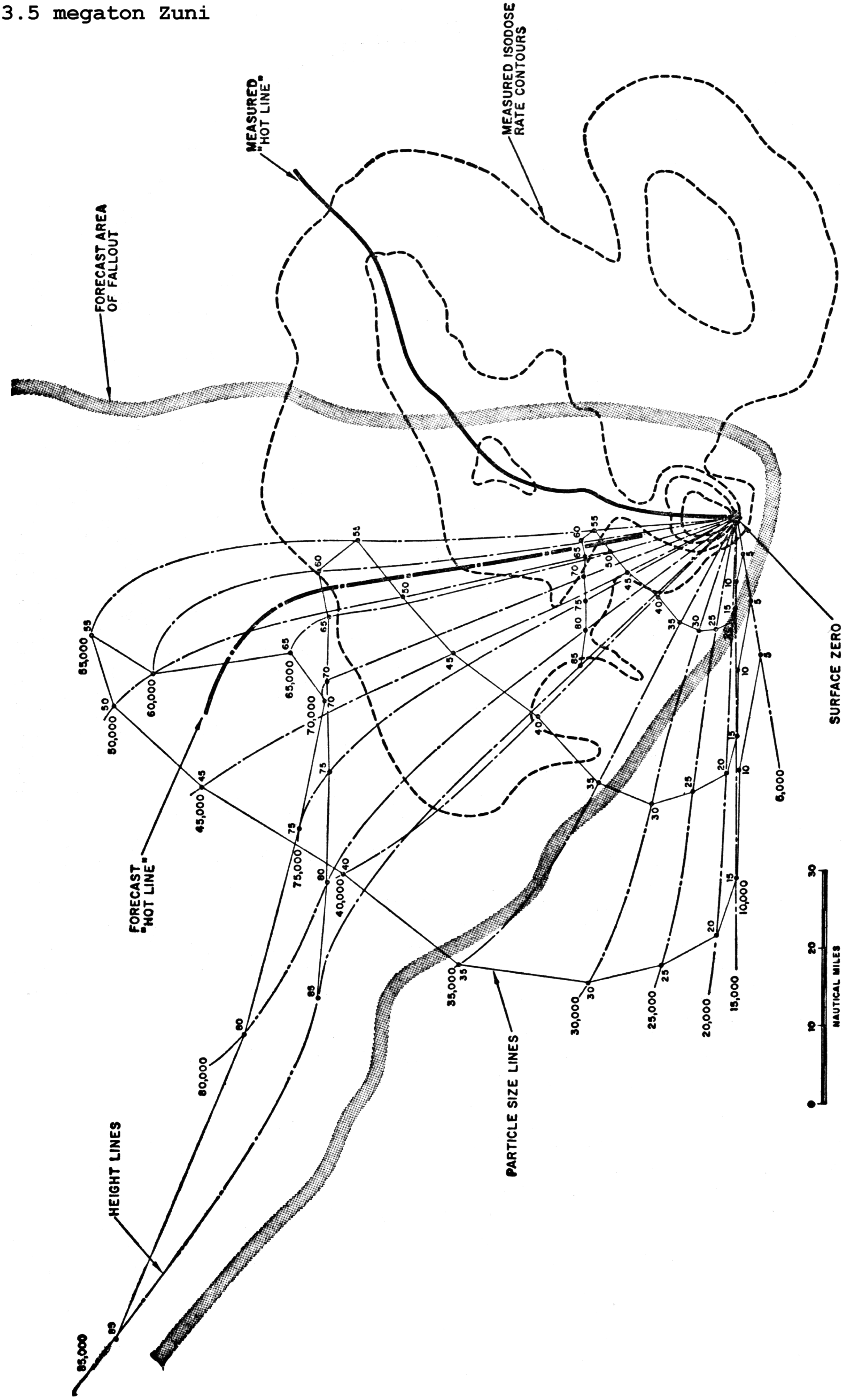
"Height lines" are deposit locations for all particles falling from a fixed altitude within the mushroom cloud. "Size lines" are deposit locations of a fixed particle size from various altitudes. A height line from the base of the mushroom disc is the "hot line".

5 megaton Tewa



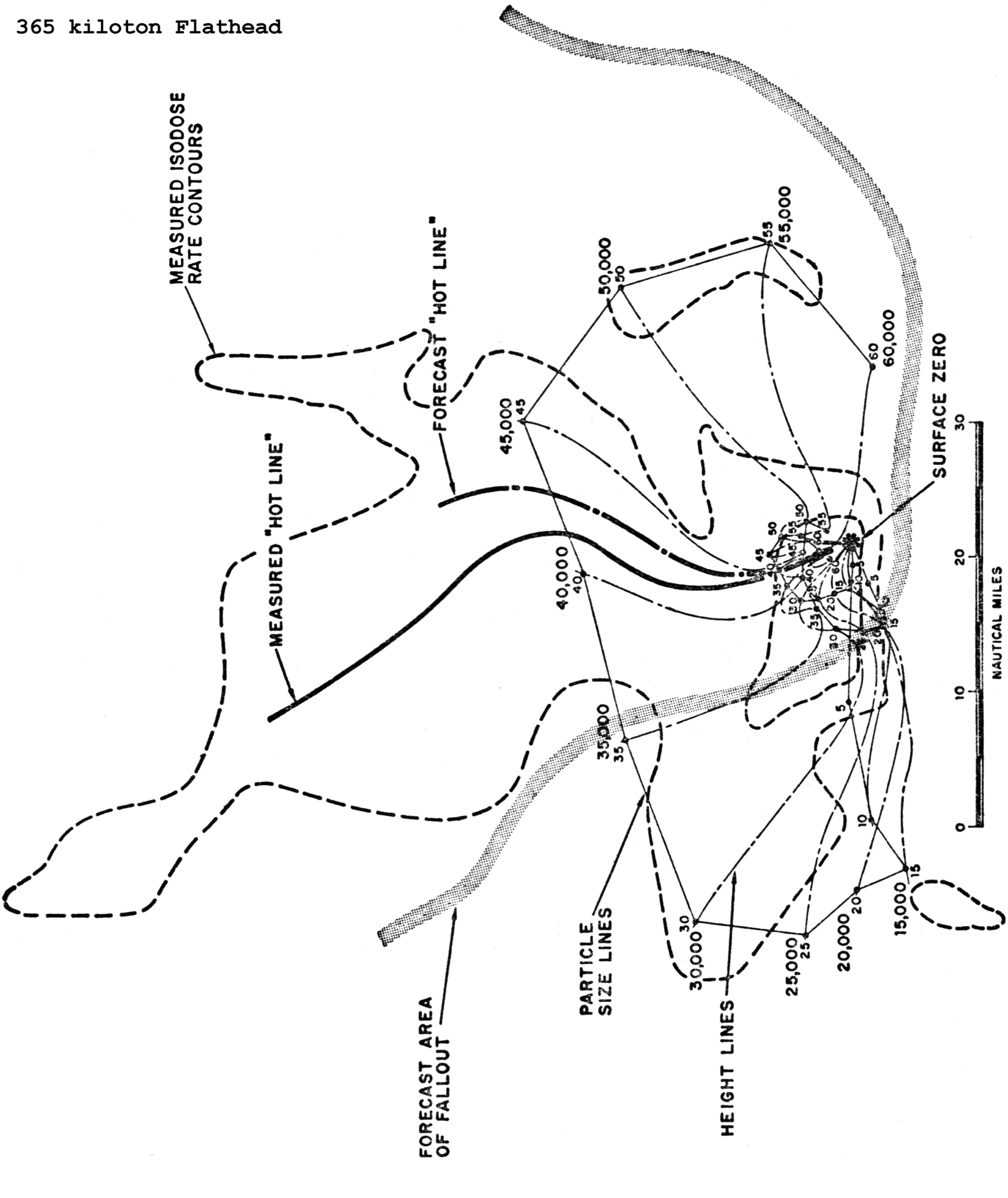
Comparison of fallout forecast with test results—shot A

3.5 megaton Zuni



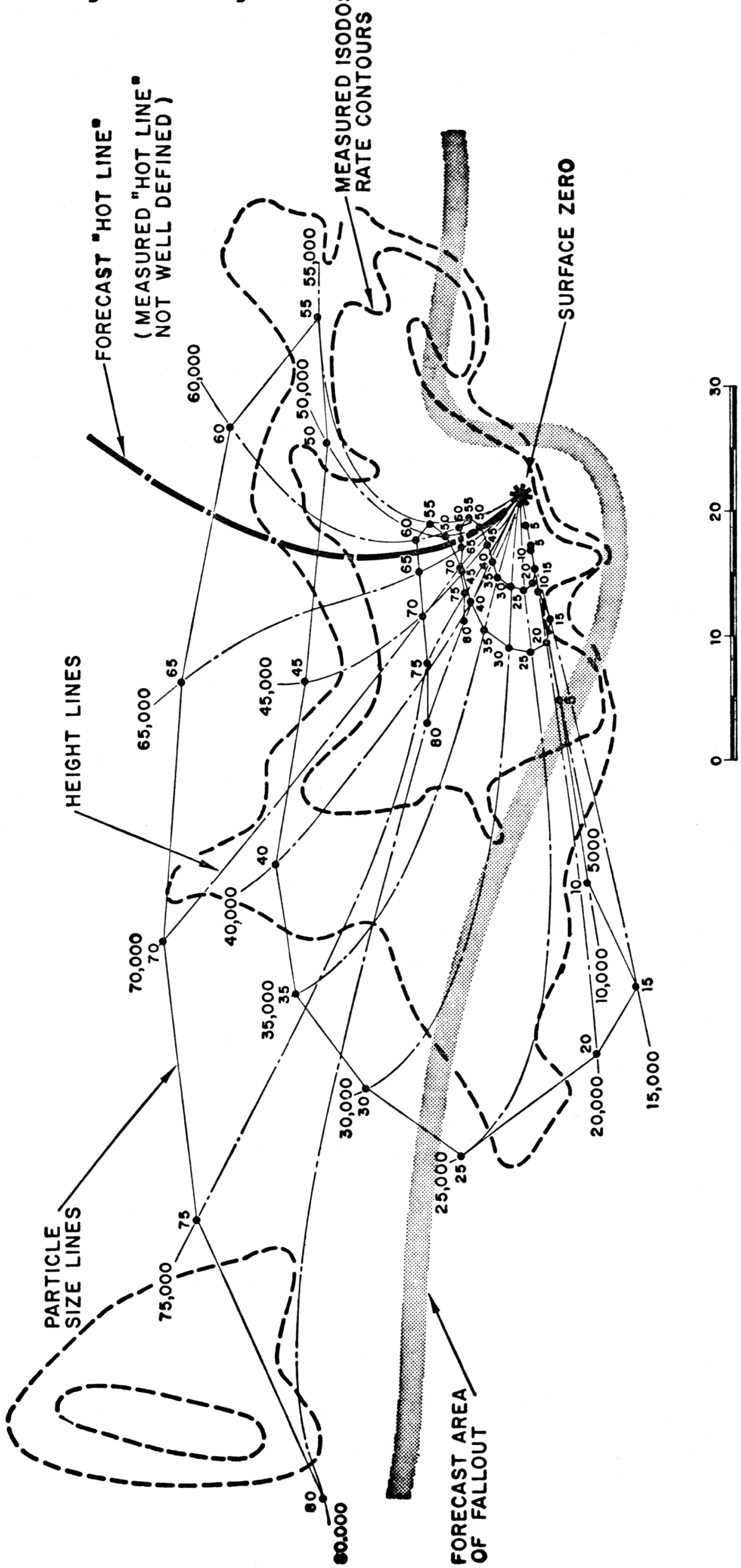
Comparison of fallout forecast with test results—shot B.

365 kiloton Flathead



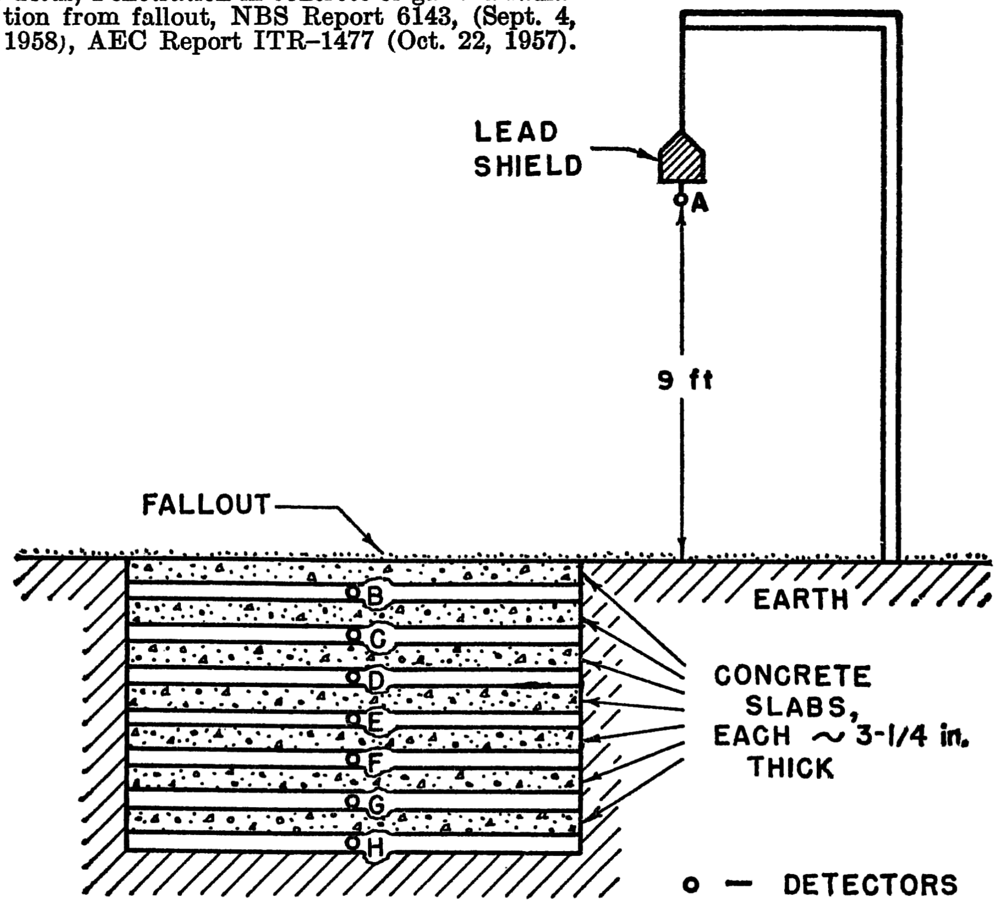
Comparison of fallout forecast with test results—shot C.

4.5 megaton Navajo

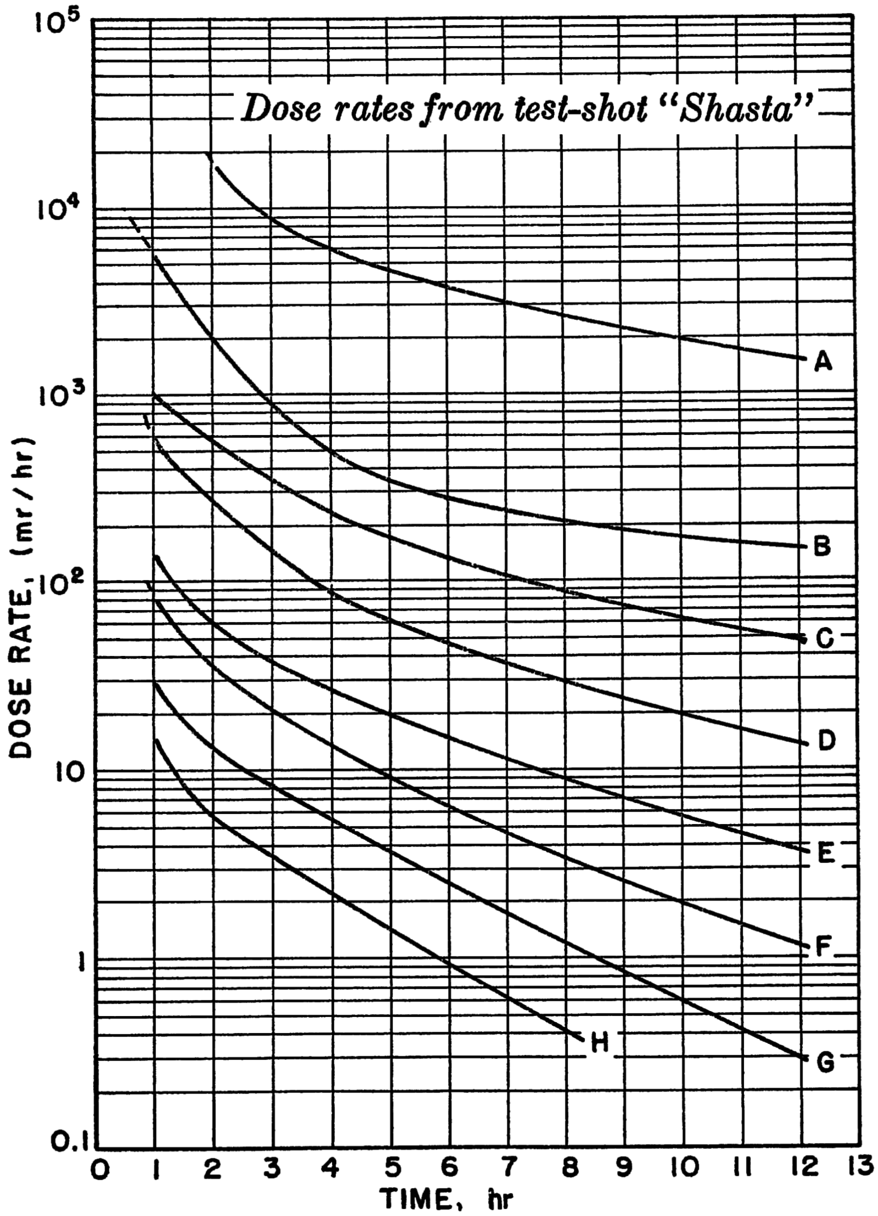


Comparison of fallout forecast with test results—shot D.

F. Titus, Penetration in concrete of gamma radiation from fallout, NBS Report 6143, (Sept. 4, 1958), AEC Report ITR-1477 (Oct. 22, 1957).



The lead shield prevents fallout material from settling directly on detector "A," while at the same time shielding against the intercepted material



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WT-615

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Report to the Scientific Director

NATURE, INTENSITY, AND DISTRIBUTION OF FALL-OUT FROM MIKE SHOT

(The first 10 megaton H-bomb test, 1952)

By

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E. A. Schuert
W. W. Perkins
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U. S. Naval Radiological Defense Laboratory
San Francisco, California

April 1953

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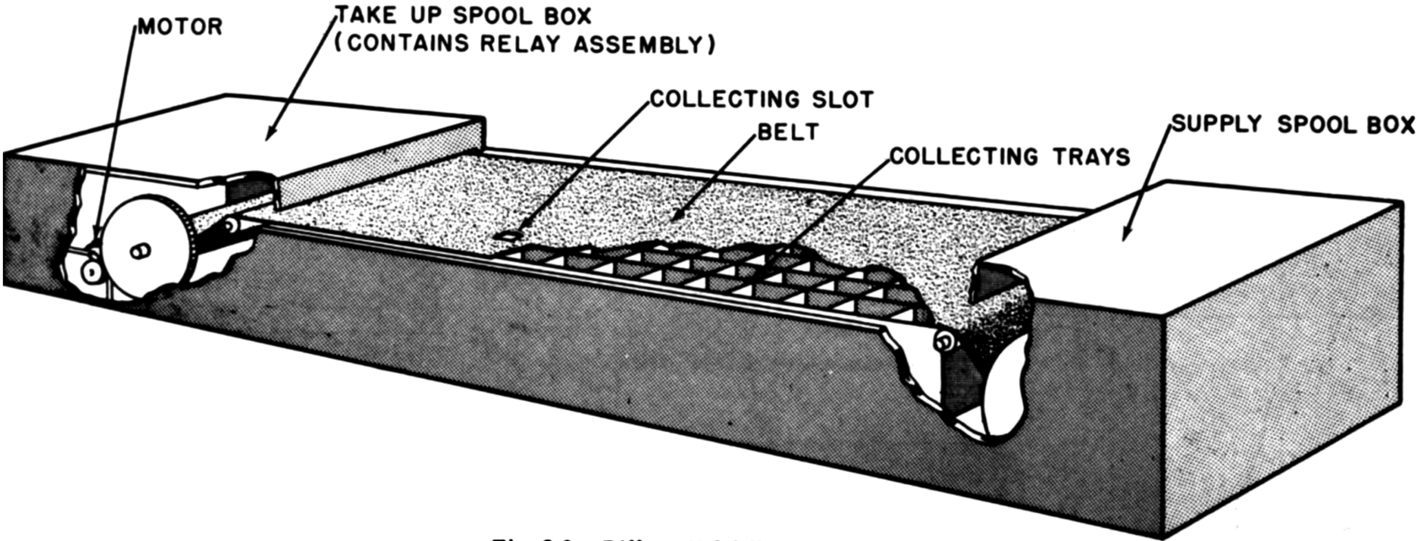

Fig. 3.2—Differential fall-out collector.

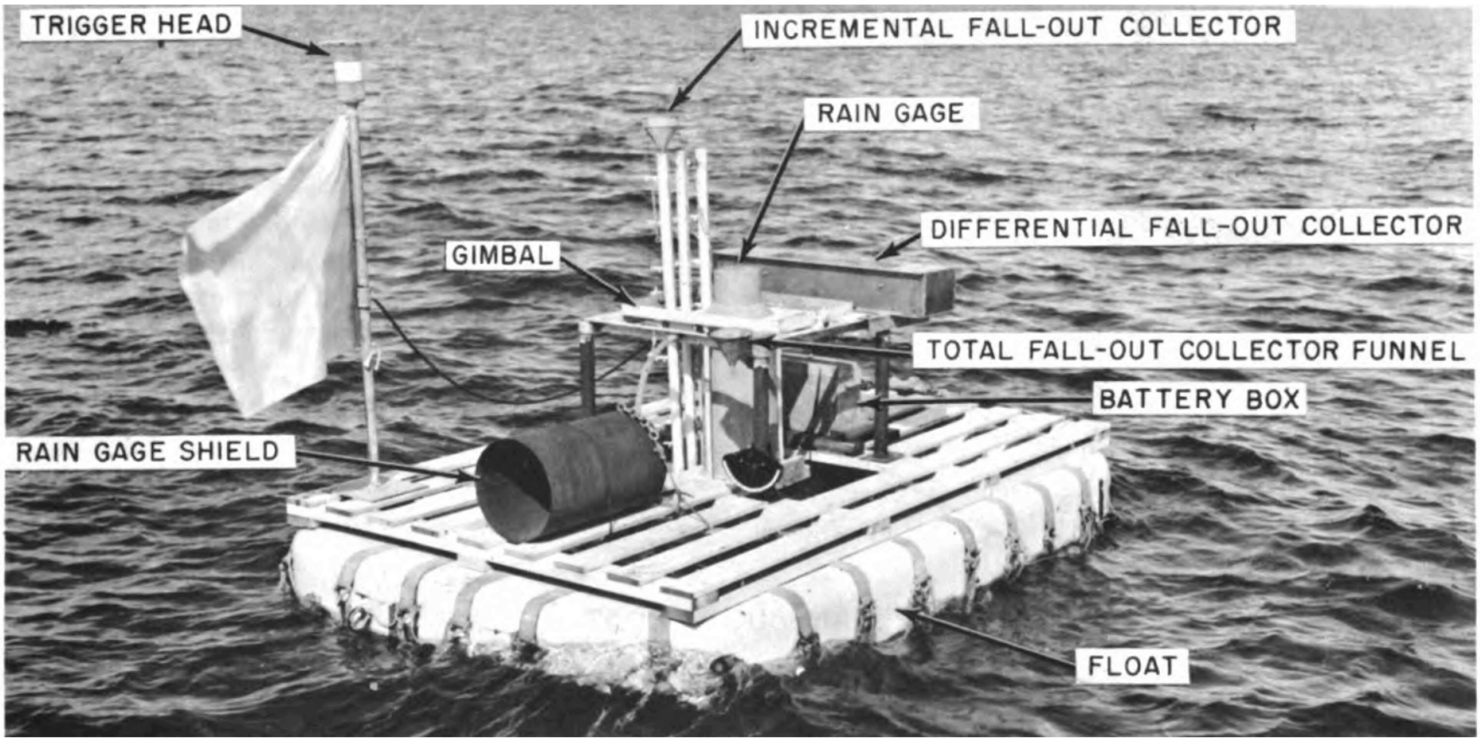

Fig. 3.9—A typical lagoon station.

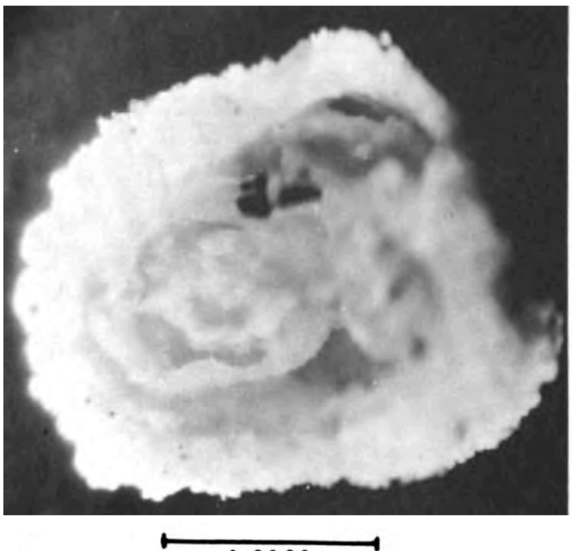

Fig. 4.4—particle removed from life-float decking

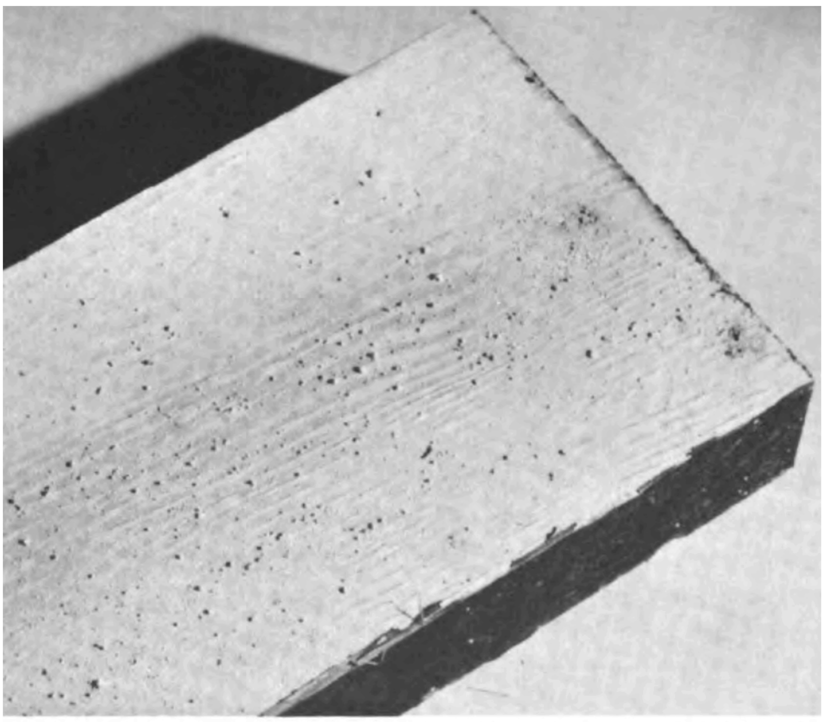

Fig. 4.6—Particle deposition on life-float decking

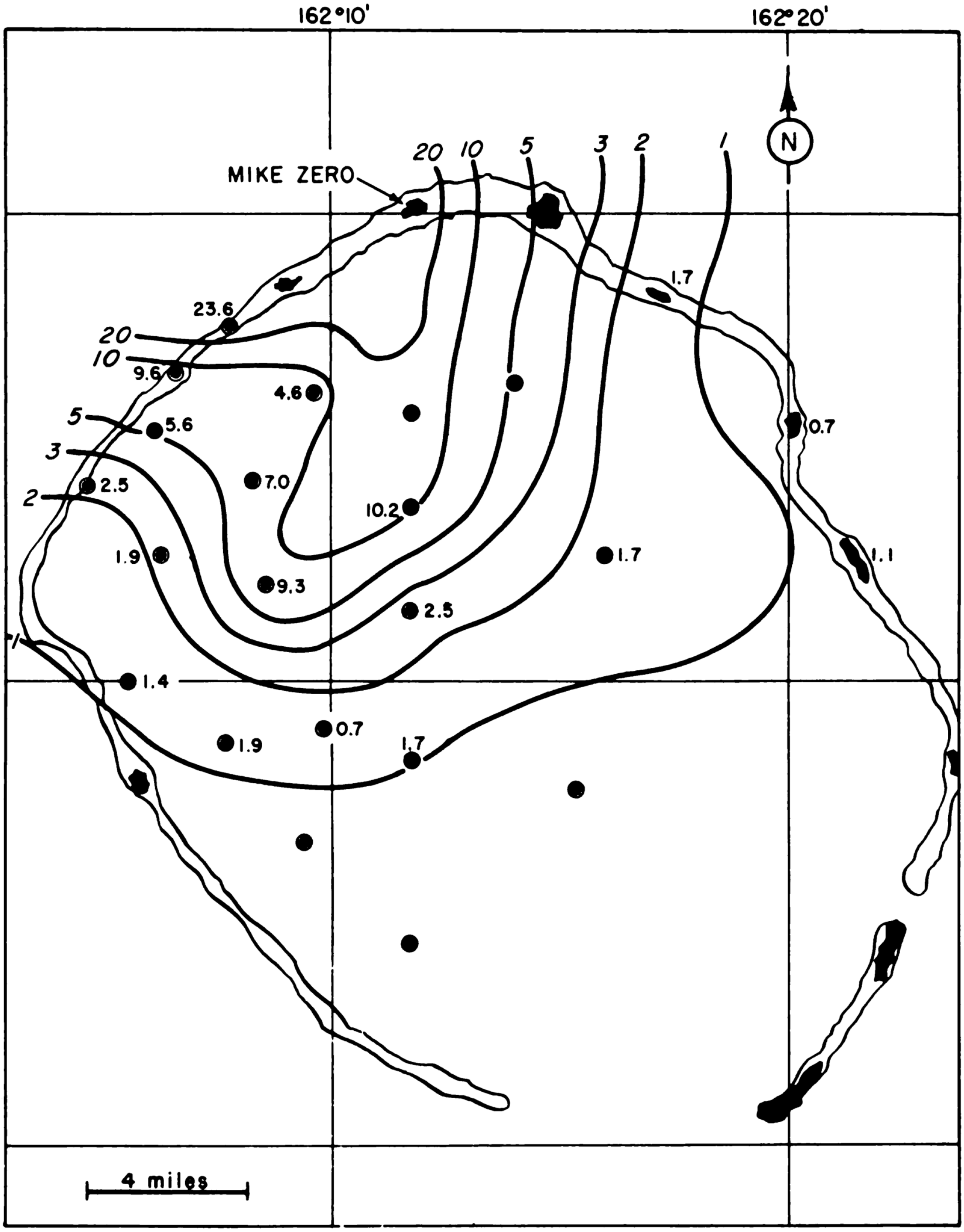

Fig. 4.8—Mass distribution of fall-out (g/sq ft).

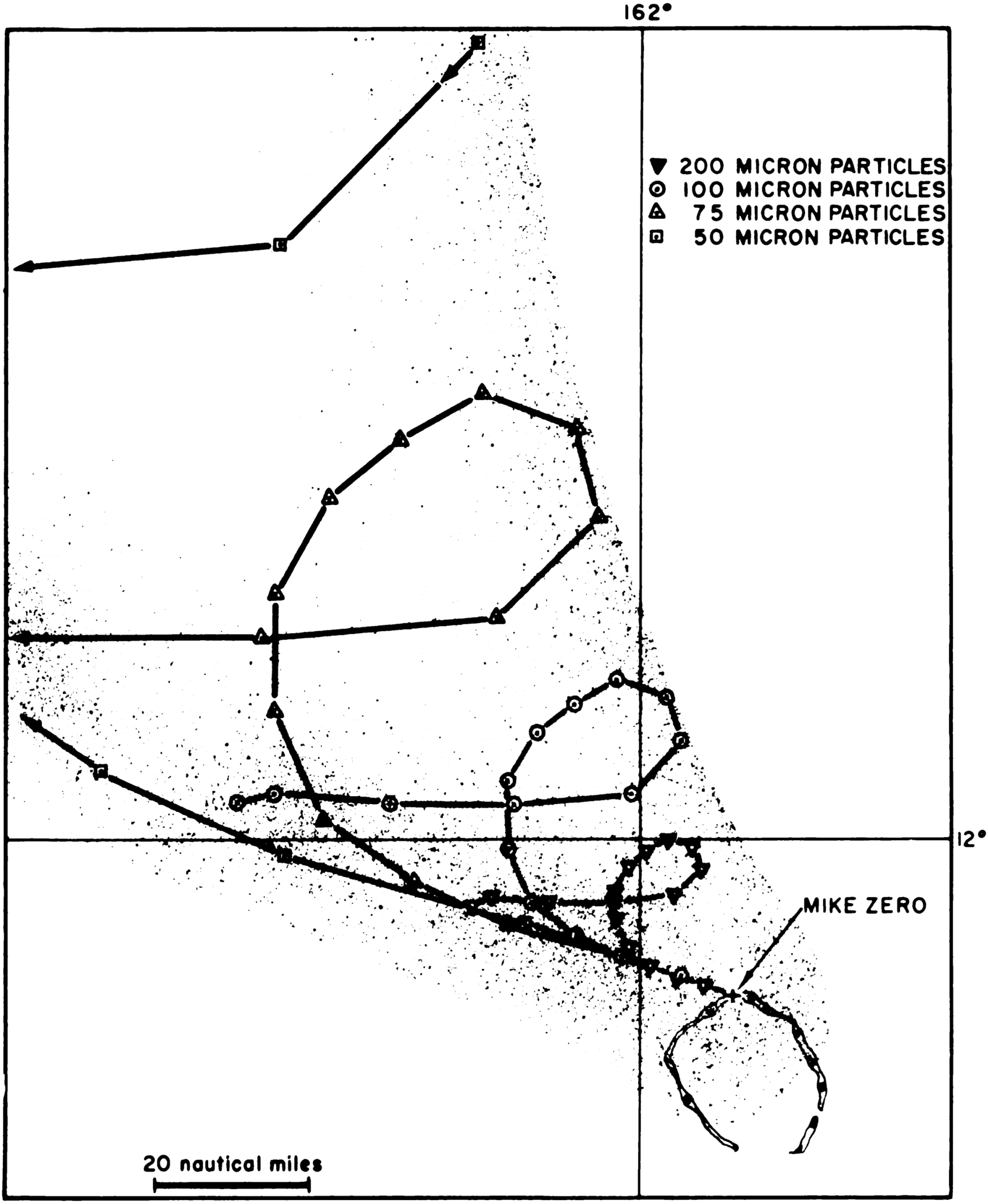

Fig. 6.1—Predicted area of primary fall-out.

HEAVY ISOTOPE ABUNDANCES IN MIKE THERMONUCLEAR DEVICE. Diamond, H. (Argonne National Lab., Ill.); Fields, P. R.; Ghioroso, A.; Thompson, S. G.; Browne, C. I.; Smith, H. L.; et al. Phys. Rev., 119: 2000-4(Sept. 15, 1960).

The Nov. 1, 1952, thermonuclear explosion ("Mike") produced all of the uranium isotopes ^{239}U, ^{240}U, ... ^{255}U through multiple neutron capture by ^{238}U. The long-lived products of successive β decays from these isotopes were measured mass spectrometrically and radiometrically. The logarithms of the abundances decline smoothly with increasing mass number; the even-mass abundances slightly exceed the geometric mean of adjacent odd-mass abundances. Some nuclear properties of neutron-rich heavy nuclides, not subject to ordinary investigation, are inferred.

NUCLEAR DECAY PROPERTIES OF HEAVY NUCLIDES PRODUCED IN THERMONUCLEAR EXPLOSIONS: PAR AND BARBEL EVENTS. Phys. Rev., 148: 1192-8(Aug. 19, 1966). (UCRL-14500).

The nuclear decay properties of heavy nuclides ($A \leq 257$) produced in two low-yield thermonuclear explosions, the Par and Barbel events, were studied with the following results. The α-decay branching of ^{253}Cf was observed, $E_\alpha = 5.978 \pm 0.005$ MeV, $\alpha/(\alpha + \beta^-) = 0.31 \pm 0.04\%$. The α-decay branching of ^{255}Es was observed, $E_\alpha = 6.300 \pm 0.003$ MeV, $\alpha/(\alpha + \beta^-) = 8.5 \pm 0.3\%$. The spontaneous fission half life of ^{250}Cm was remeasured and was found to be $1.74 \pm 0.24 \times 10^4$ years. Upper limits for the half lives of ^{252}Cm and ^{251}Bk were set at 2 and 3 days, respectively. The existence of 80-day ^{257}Fm was confirmed; a sample of ^{257}Fm from the Par event decayed with a half life of 94 ± 10 days.

(LA-DC-8103) PRODUCTION OF HEAVY ELEMENTS IN A RECENT LOS ALAMOS THERMONUCLEAR TEST. Hoffman, Darleane C. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). [1966]. Contract W-7405-eng-36. 8p. (CONF-660817-3). Dep. mn.

A low-yield thermonuclear device, designed to give a high-neutron-flux region for the purpose of producing heavy elements by multiple-neutron capture, was recently tested underground in Nevada. This device, Cyclamen, containing ^{238}U and ^{243}Am target material, was the most successful heavy element producer to date, giving an order of magnitude more ^{257}Fm than any previous Nevada test.

FISSION AND THE SYNTHESIS OF HEAVY NUCLEI BY RAPID NEUTRON CAPTURE. Bell, George I. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-eng-36. Phys. Rev., 158: 1127-41(June 20, 1967). (LA-DC-8513).

The role of fission is examined in the synthesis of heavy nuclei by multiple capture of neutrons in thermonuclear explosions. Evidence from the recent Tweed and Cyclamen experiments indicating that neutron-induced fission is a serious source of depletion in neutron capture chains which start from targets of ^{242}Pu and ^{243}Am is reviewed.

BIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NUCLEAR WAR

HEARINGS

BEFORE THE

SPECIAL SUBCOMMITTEE ON RADIATION

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

ON

BIOLOGICAL AND ENVIRONMENTAL EFFECTS
OF NUCLEAR WAR

JUNE 22, 23, 24, 25, AND 26, 1959

PART 1

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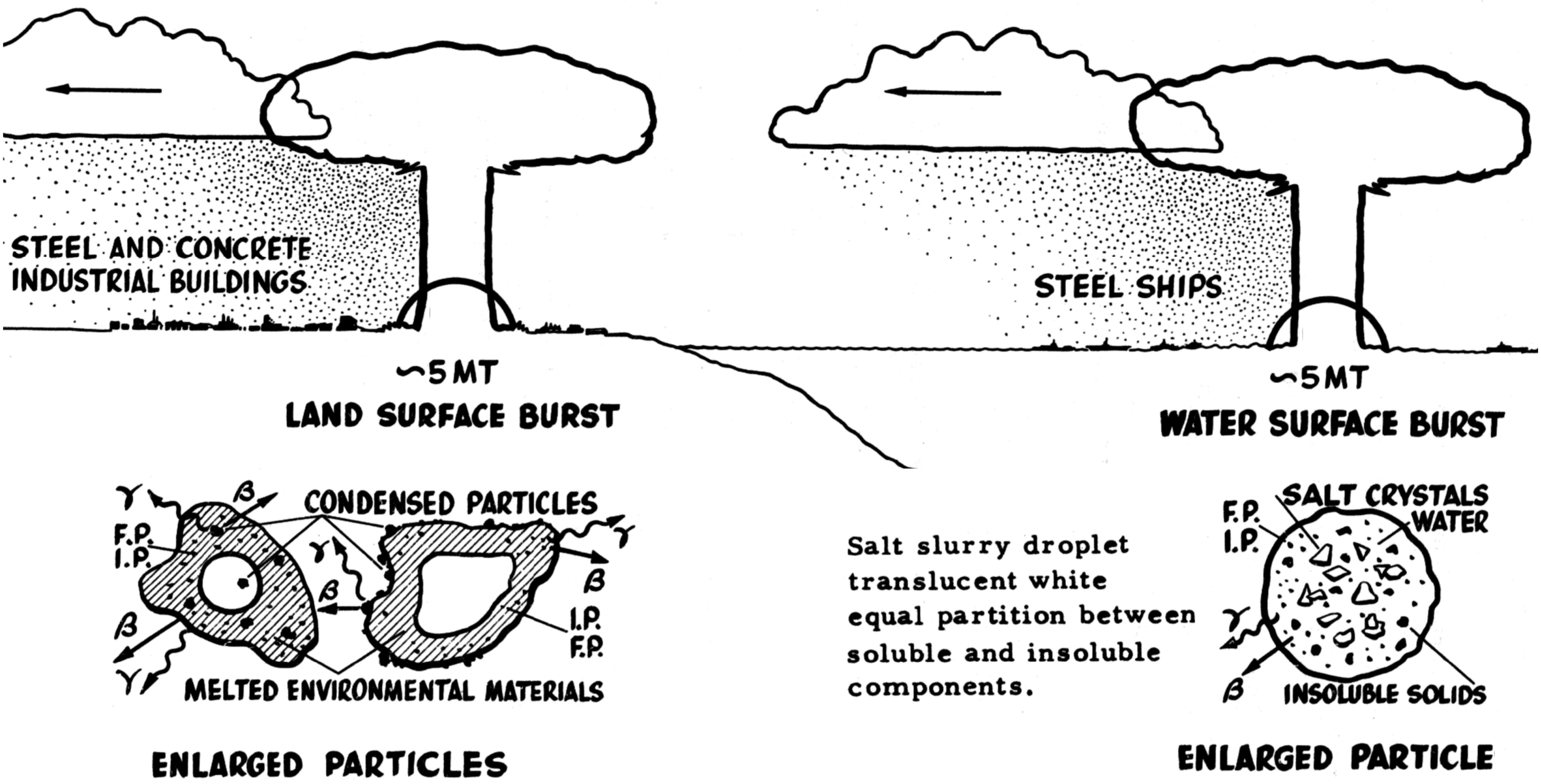
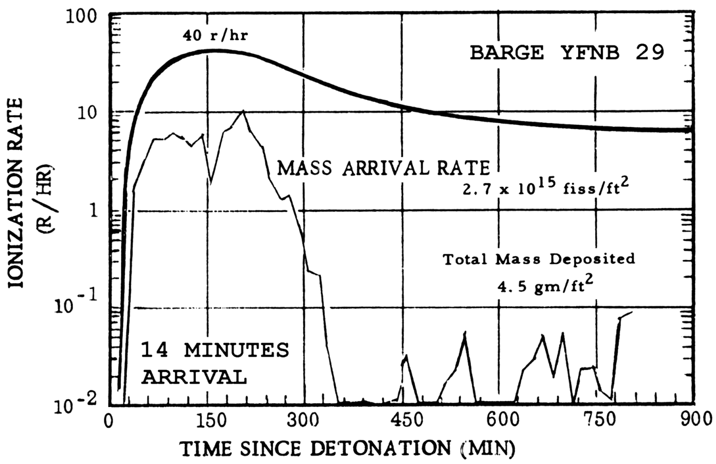


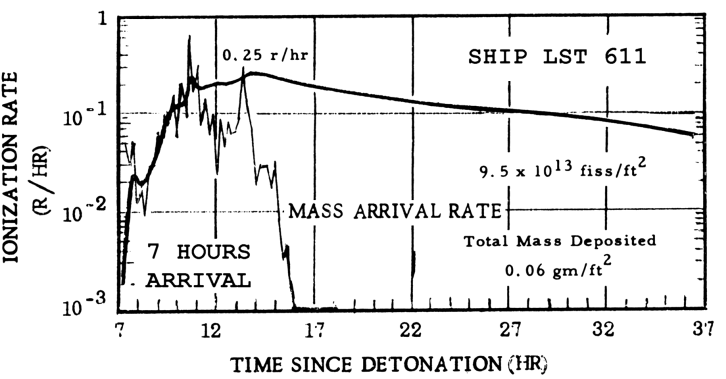
Triffet, T. and LaRiviere, P. D.; Characterization of Fallout, Volume I; Operation REDWING, Project 2.63, Final Report, August 1958

ARRIVAL CHARACTERISTICS OF LAND SURFACE BURST FALLOUT

5 MT TEWA (87% FISSION), 7.84 STAT. MILES WSW

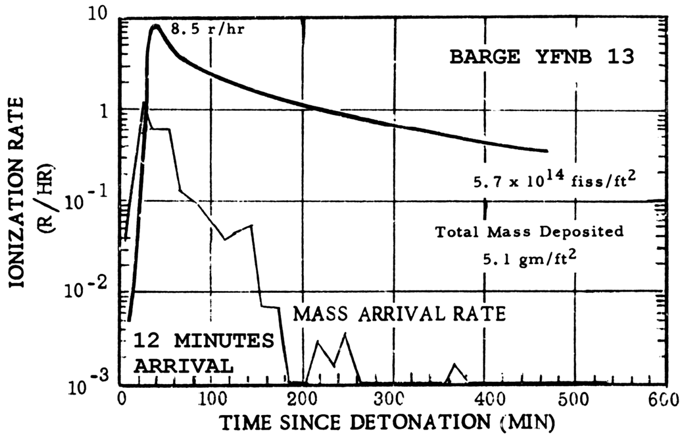


5 MT TEWA (87% FISSION), 59.3 STAT. MILES NW

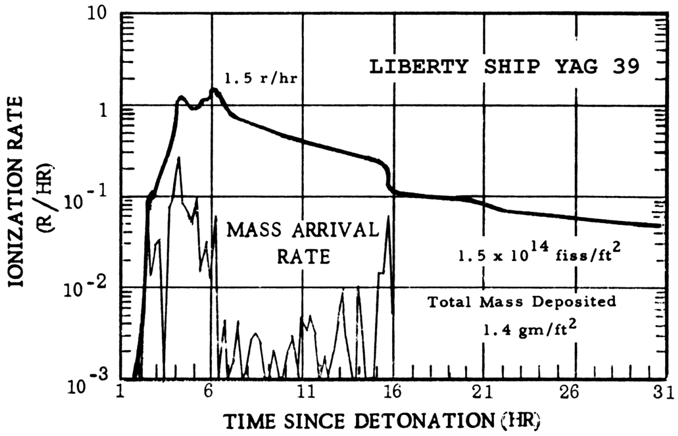


ARRIVAL CHARACTERISTICS OF WATER SURFACE BURST FALLOUT

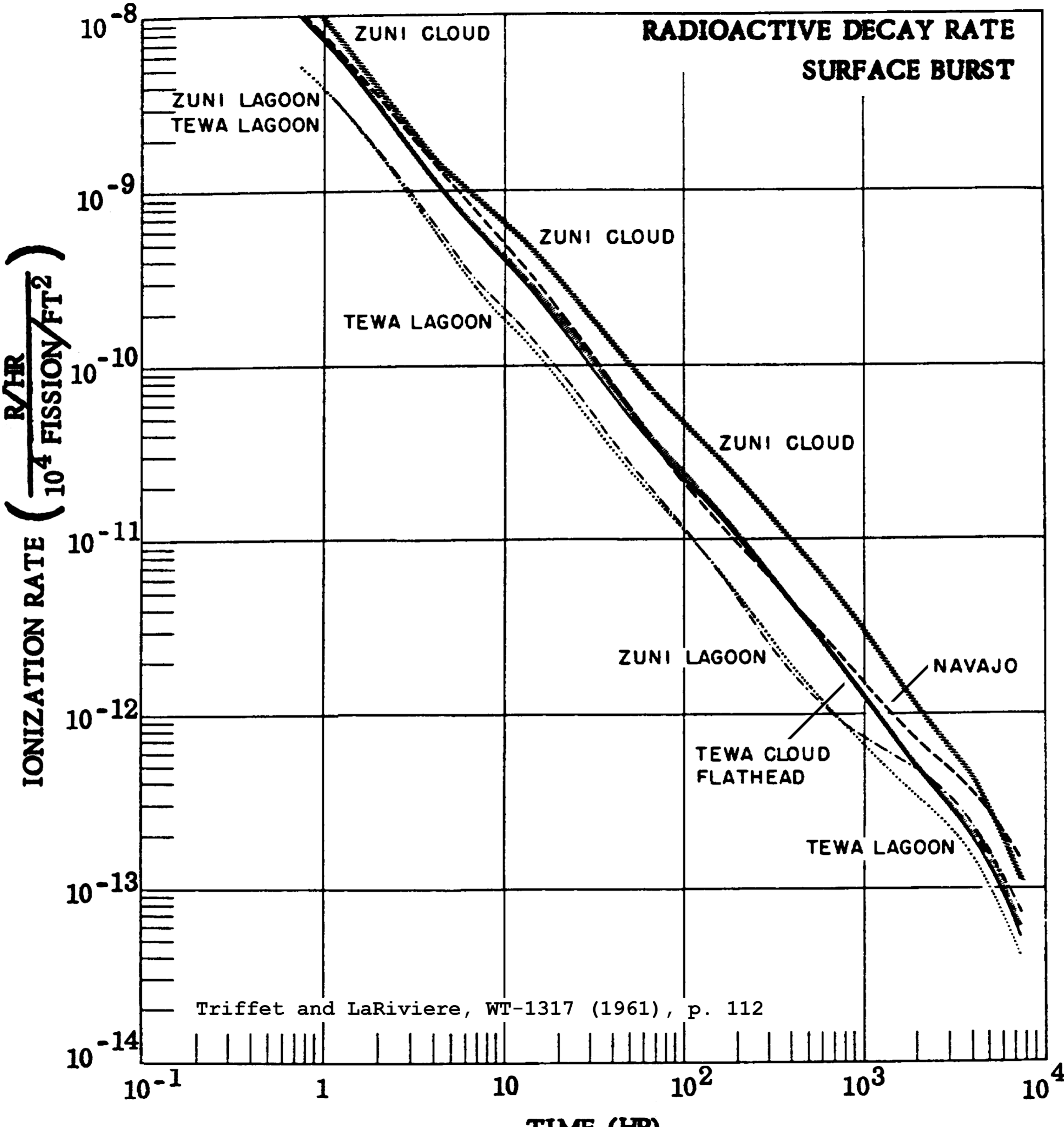
4.5 MT NAVAJO (5% FISSION), 7.54 STAT. MILES W



4.5 MT NAVAJO (5% FISSION), 21.0 STAT. MILES N



DATA: USNRDL-466 PAGES 20-21
WT-1317 PAGE 61


RADIOACTIVE DECAY RATE
SURFACE BURST
ZUNI CLOUD
ZUNI LAGOON
TEWA LAGOON
ZUNI CLOUD
TEWA LAGOON
ZUNI CLOUD
ZUNI LAGOON
NAVAJO
TEWA CLOUD
FLATHEAD
TEWA LAGOON
Triffet and LaRiviere, WT-1317 (1961), p. 112
IONIZATION RATE $\left(\frac{R/HR}{10^4\ FISSION/FT^2}\right)$
TIME (HR)
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-1}
1
10
10^2
10^3
10^4

RADIATION CHARACTERISTICS OF LAND SURFACE BURST FALLOUT

	8 mi downwind	60 mi downwind
Average γ Energy		
1 hr	--	1.0 mev
2 hr	--	0.95
1/2 day	--	0.60
1 day	--	0.40
1 week	0.25 mev	0.35
1 mo	0.45	0.65

RADIATION CHARACTERISTICS OF WATER SURFACE BURST FALLOUT

	7 mi downwind	22 mi downwind
Average γ Energy		
1 hr		1.0 mev
2 hr		0.95
1/2 day		0.60
1 day		0.40
1 week		0.35
1 mo		0.65

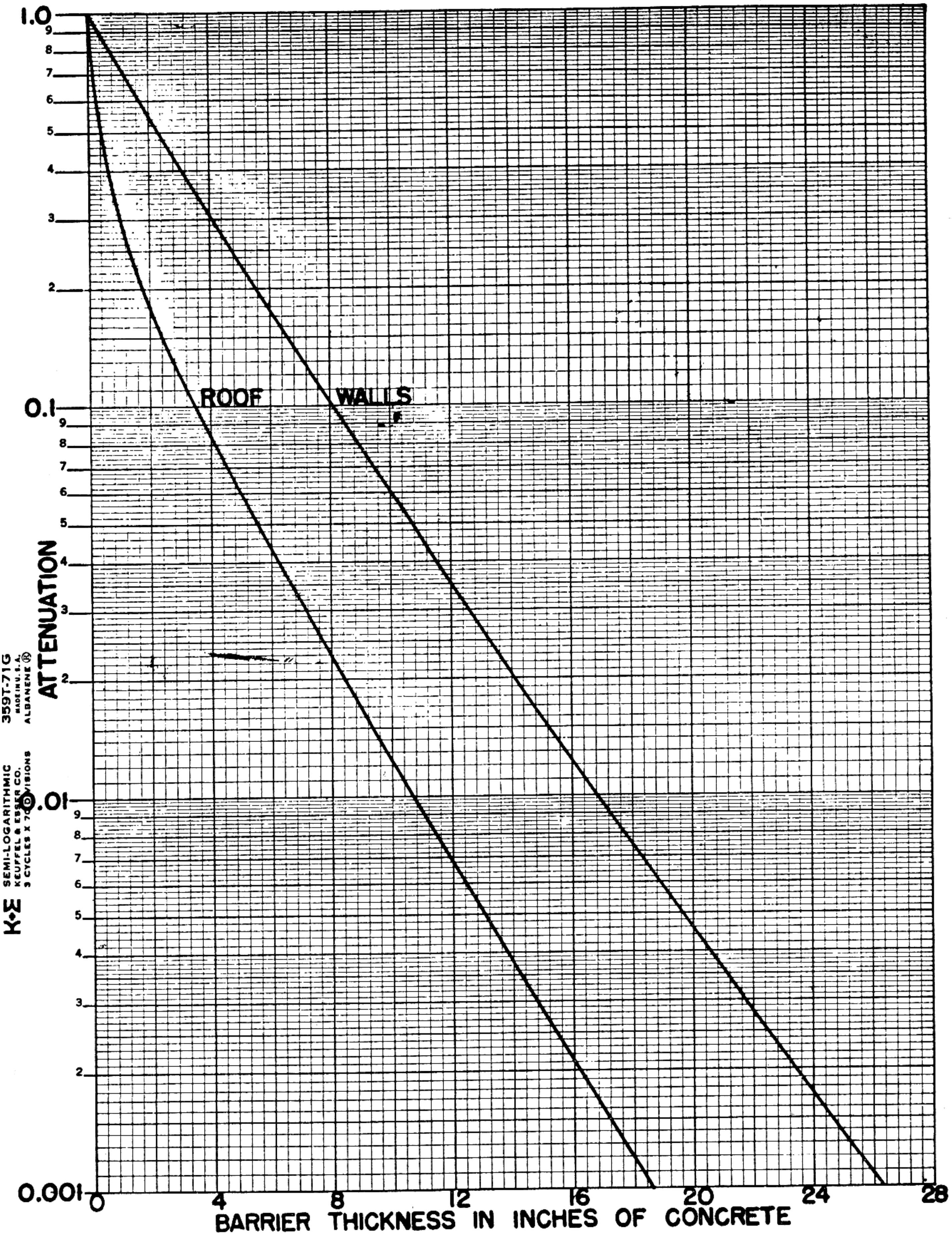


FIGURE 6.—Attenuation of gamma radiation dose as a function of concrete barrier thickness. The curve labeled "roof" gives attenuation of radiation from roof sources as it penetrates the roof and floors. The curve labeled "walls" gives the attenuation of radiation from ground sources as it penetrates the walls. Both curves were calculated for the energy distribution of fission product gamma rays at 1 hour after weapon burst.

III. NATIONAL ACADEMY OF SCIENCES ADVISORY COMMITTEE ON CIVIL DEFENSE, SUBCOMMITTEE ON RADIATION SHIELDING

In the problem of shielding from fallout radiation, as well as in all scientific work, it is important that the theoretical and the experimental work be closely coordinated. With this in mind, the Advisory Committee on Civil Defense of the National Academy of Sciences formed a Subcommittee on Radiation Shielding. This subcommittee is composed of people who are actively engaged in either calculations or experiments. It includes representatives from the Office of Civil and Defense Mobilization, the National Bureau of Standards, Oak Ridge National Laboratory, the Defense Atomic Support Agency, the Naval Radiological Defense Laboratory, Technical Operations, Inc., and the University of California. It was formed last October and has met approximately once every 3 months. This subcommittee also serves in an advisory capacity to OCDM in directing its research efforts on radiation shielding.

TABLE 1.—*Categorization of shelter areas*

Category	Protection factor	Typical examples
A	1,000 or greater	1. OCDM underground shelters. 2. Subbasements of multistory buildings. 3. Underground installations (mines, tunnels, etc.).
B	250 to 1,000	1. OCDM basement fallout shelters (heavy masonry residences). 2. Basements (without exposed walls) of multistory buildings.
C	50 to 250	1. OCDM basement fallout shelters (frame and brick veneer residences). 2. Central areas of basements (with partially exposed walls) of multistory buildings. 3. Central areas of floors near midheight of large multistory buildings with heavy exterior walls and floors.
D	10 to 50	1. Basements (without exposed walls) of small 1- or 2-story buildings. 2. Central areas of floors near midheight of large multistory buildings with light exterior walls and floors.
E	2 to 10	1. Basements (partially exposed) of small 1- or 2-story buildings. 2. Central areas of lower floors in large multistory buildings. 3. Central areas on ground floor in 1- or 2-story buildings with heavy masonry walls.
F	1½ to 2	1. Aboveground areas of low buildings, in general, including residences stores, factories, etc.

TABLE 2.—*Shielding factors in some typical light residential structures* [1]

[Values deduced from experiment]

Structure	Location	Reduction factors [2]: Roof contribution	Reduction factors [2]: Ground contribution	Reduction factors [2]: Total	Protection factor [3]
2 story wood frame house	2d floor center	0.076	0.50	0.58	1.7
	1st floor center	.034	.57	.60	1.7
	Basement center	.015	.028	.043	[4] 23
1 story wood rambler	1st floor center	.10	.54	.64	1.6
2 story brick veneer house	do	.034	.14	.17	[5] 6
	Basement center	.015	.021	.036	[4] 28

[1] Values in this table are from an NBS report, to be published. (Ref. 17.)
[2] Reduction factor is defined as dose rate at the specified location divided by the dose rate outside at 3 feet above the ground.
[3] Protection factor is defined as dose rate at 3 feet above the ground, outside, divided by the dose rate at the specified location.
[4] This factor applies to basements with no exposed walls.
[5] This factor applies only for detector locations below window sill level

MYRON HAWKINS:

the induced radiation in uranium 238. We can refer to a British report which indicates that around 60 percent of the total activity at 4 days—activity in this case is the number of disintegrations—is due to the uranium 239 and neptunium 239 that are produced, as the British say, in either large or small weapons. I believe part of the hump on the curves in the early times, say around 4 days, is largely due to this.

Dr. TRIFFET. Yes. I thought this might be an appropriate place to comment on the variation of the average energy. It is clear when you think of shielding, because the effectiveness of shielding depends directly on the average energy radiation from the deposited material. As I mentioned, Dr. Cook at our laboratory has done quite a bit of work on this. What it amounts to is that at one hour the average energy is about one Mev. This appears, by the way, in the tables that are in my written statement but that I did not present orally.

Representative HOLIFIELD. Mev. means?

Dr. TRIFFET. Million electron volts. At 2 hours it drops to 0.95. At a half day, to 0.6. At 1 week it drops to 0.35. Then it begins to go up again. At 1 month, it is 0.65, 2 months 0.65. The meaning of this is simply that there is a period around 1 week when if induced products are important in the bomb, there are a lot of radiations emanating from these, but the energy is low so it operates to reduce the average energy in this period and shielding is immensely more effective.

Strontium 90, for example, has 33-second krypton as its birth predecessor; cesium 137 derives from a fission chain headed up by 22-second iodine, followed by 3.9-minute xenon. Because of their volatile or gaseous ancestry in the fireball or bomb cloud a number of the high-yield fission products are formed in finely divided particles. Some of these are so small that they are not subject to gravitational settling, and in fact they remain suspended in the earth's atmosphere for many years, providing[6] that they reach the stratosphere at the proper latitude. In any event such fission products would be depleted in the local fallout.

For example, the irradiation of uranium^{238} with low Mev. neutrons forms neptunium 239, a 2.3-day radioelement which W. J. Heiman[7] estimates might constitute 50 percent of the residual activity a few days after a bomb detonation.

At higher neutron energies, such as certain types of thermonuclear weapons produce, natural uranium undergoes an (n,2n) reaction which competes with fast fission in U^{238}. The data of R. J. Howerton[8] show that U^{238} has a fission cross section of 0.6 barn from 2 to 6 Mev., thereafter climbing to a plateau value of 1 barn for neutrons up to 14 Mev. At 6.6 Mev. there is a threshold for the (n,2n) reaction and the reaction has a cross section of 1.4 barns in the range of 10 Mev. The ready identification of U^{237} in fallout points to fast fission of U^{238} as a main energy source in high-yield megaton-class weapons.

[6] See E. A. Martell, "Atmospheric Circulation and Deposition of Strontium 90 Debris," Air Force Cambridge Research Center paper (July 1958). See also W. F. Libby, "Radioactive Fallout," speech of Mar. 13, 1959.
[7] Variation of Gamma Radiation Rates for Different Elements Following an Underwater Nuclear Detonation," J. Colloid. Science, 13 (1958), p. 329.
[8] "Reaction Cross Sections of U^{238} in the Low Mev. Range," UCRL 5323 (Aug. 15, 1958).

RADIOACTIVE FALLOUT AND ITS EFFECTS ON MAN pages 1689-1691

A. E. R. E. HP/R 2017

ATOMIC ENERGY RESEARCH ESTABLISHMENT

THE RADIOLOGICAL DOSE TO PERSONS IN THE U. K. DUE TO DEBRIS FROM NUCLEAR TEST EXPLOSIONS PRIOR TO JANUARY 1956

By N. G. Stewart, R. N. Crooks, and Miss E. M. R. Fisher

Activity from Neutron Capture

Although several different radioactive elements may be created by the capture of neutrons in materials close to the reacting core of a weapon, the only significant reactions to produce gamma-ray emitters are those associated with the natural uranium which may be used as the tamper material of the bomb.

neutron (low energy) + U-238 ⟶ U-239 ⟶ Np-239

Chemical analysis of the debris shows that in general about one neutron is captured in this way for every fission that occurs, both in nominal bombs and in thermonuclear explosions. The U^{239} decays completely before reaching the U.K. but at four days after time of burst the Np^{239} disintegration rate reaches a peak relative to that of the fission products and accounts for about 60% of the observed activity at that time.

In addition to this, a smaller number of the neutrons in a thermonuclear explosion undergo an (n,2n) reaction with U^{238} to form 6.7 day U^{237} which is also a (β, γ) emitter.

neutron (high energy) + U-238 ⟶ 2 neutrons + U-237

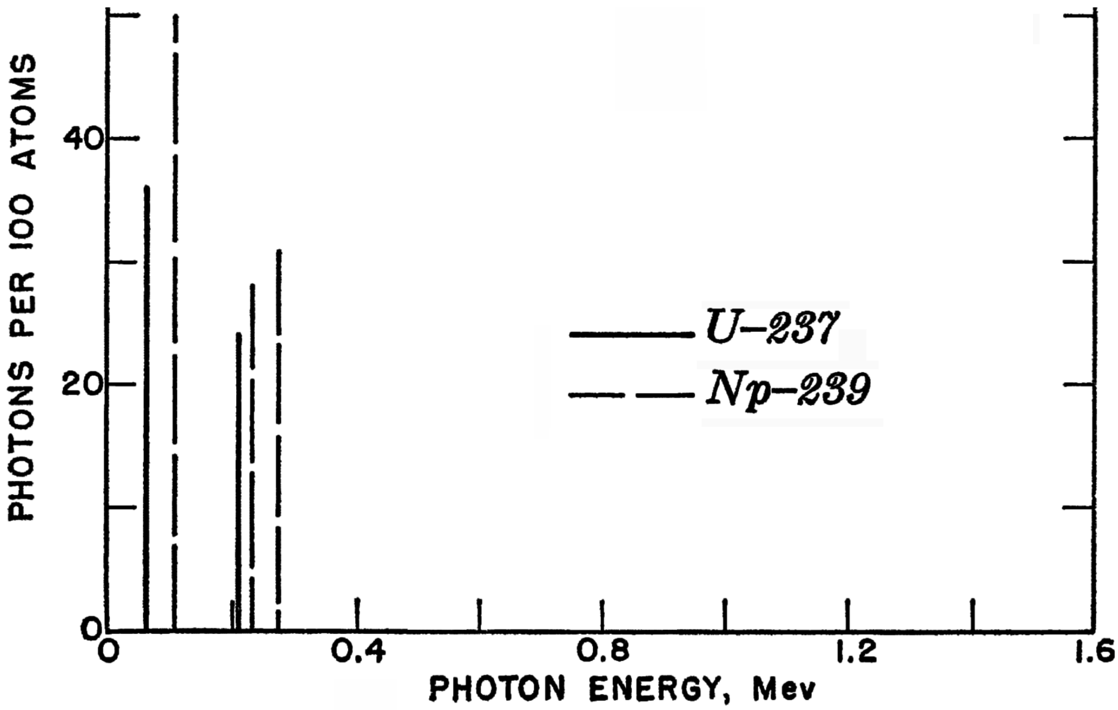


FIGURE 1

FIGURE 1.—Extensive lesions, 46 days after exposure, on a young boy who wore little clothing at the time of exposure. Note particularly the lesions on the neck, in the armpits and at the beltline—areas where the fallout material tended especially to collect.

FIGURE 2

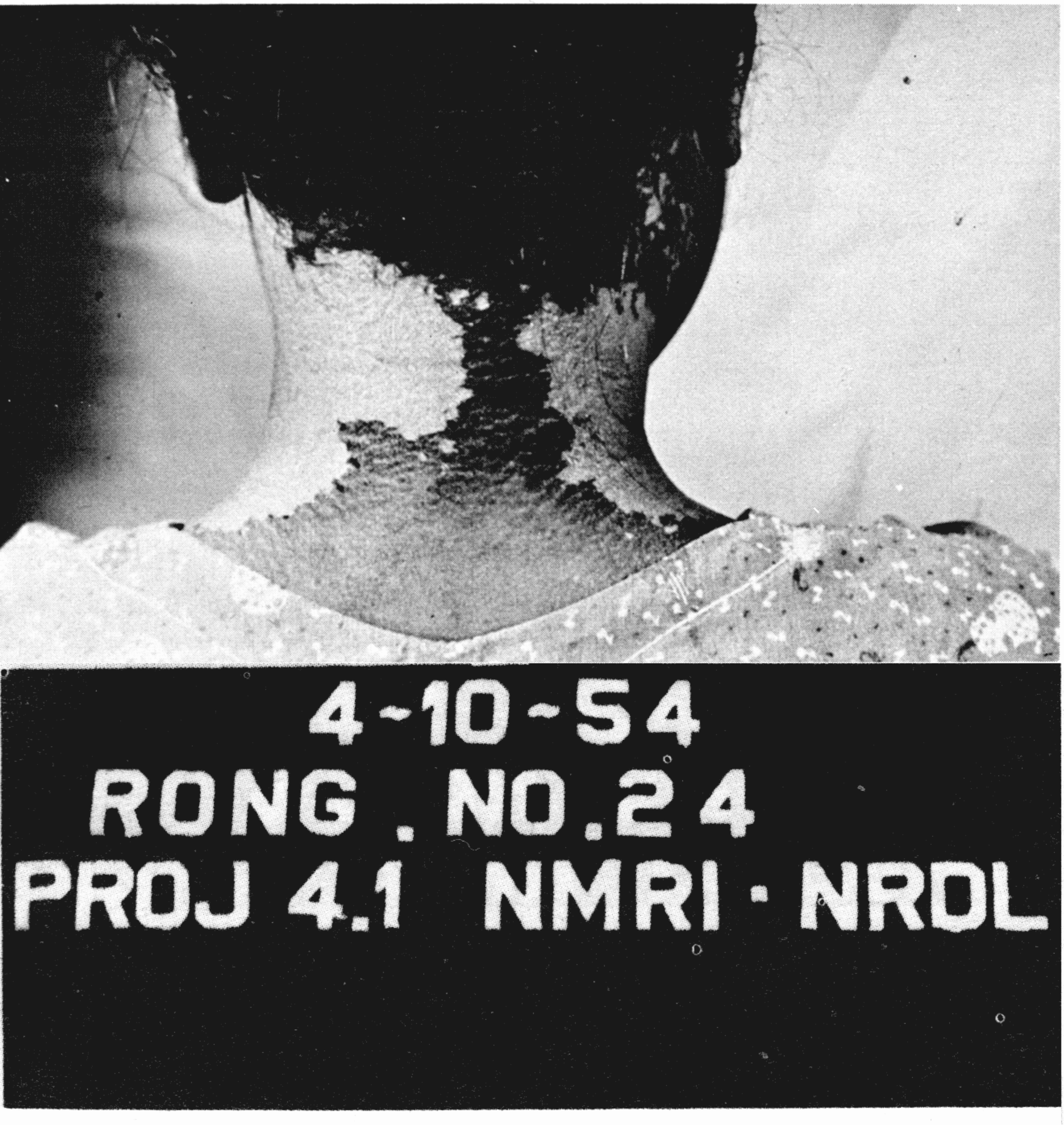


FIGURE 2.—Extensive neck lesions on a woman approximately 30 days after exposure. Note the superficial nature of the lesions, resembling severe sunburn.

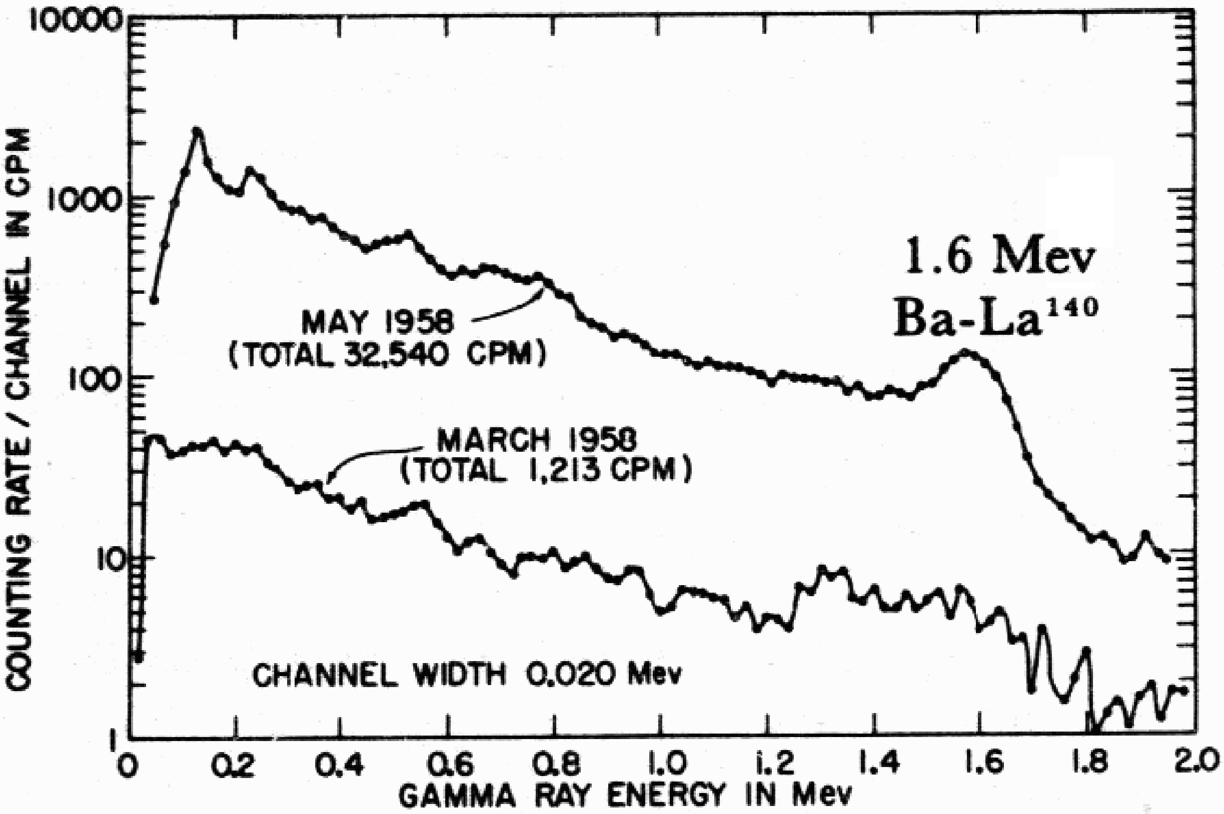


Figure 16. Background counting rates at Rongelap Atoll.

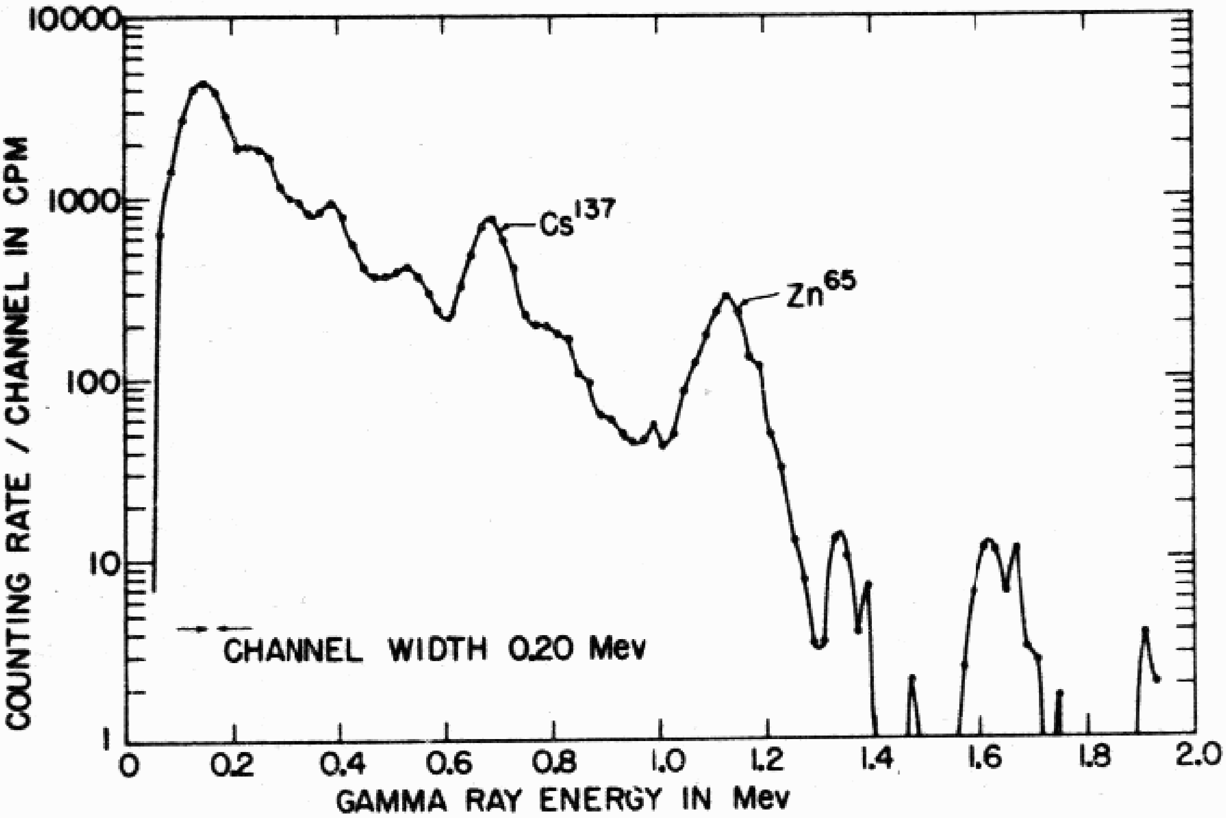


Figure 17. Rongelap subject #50, May 1958, total 43,260 cpm above background.

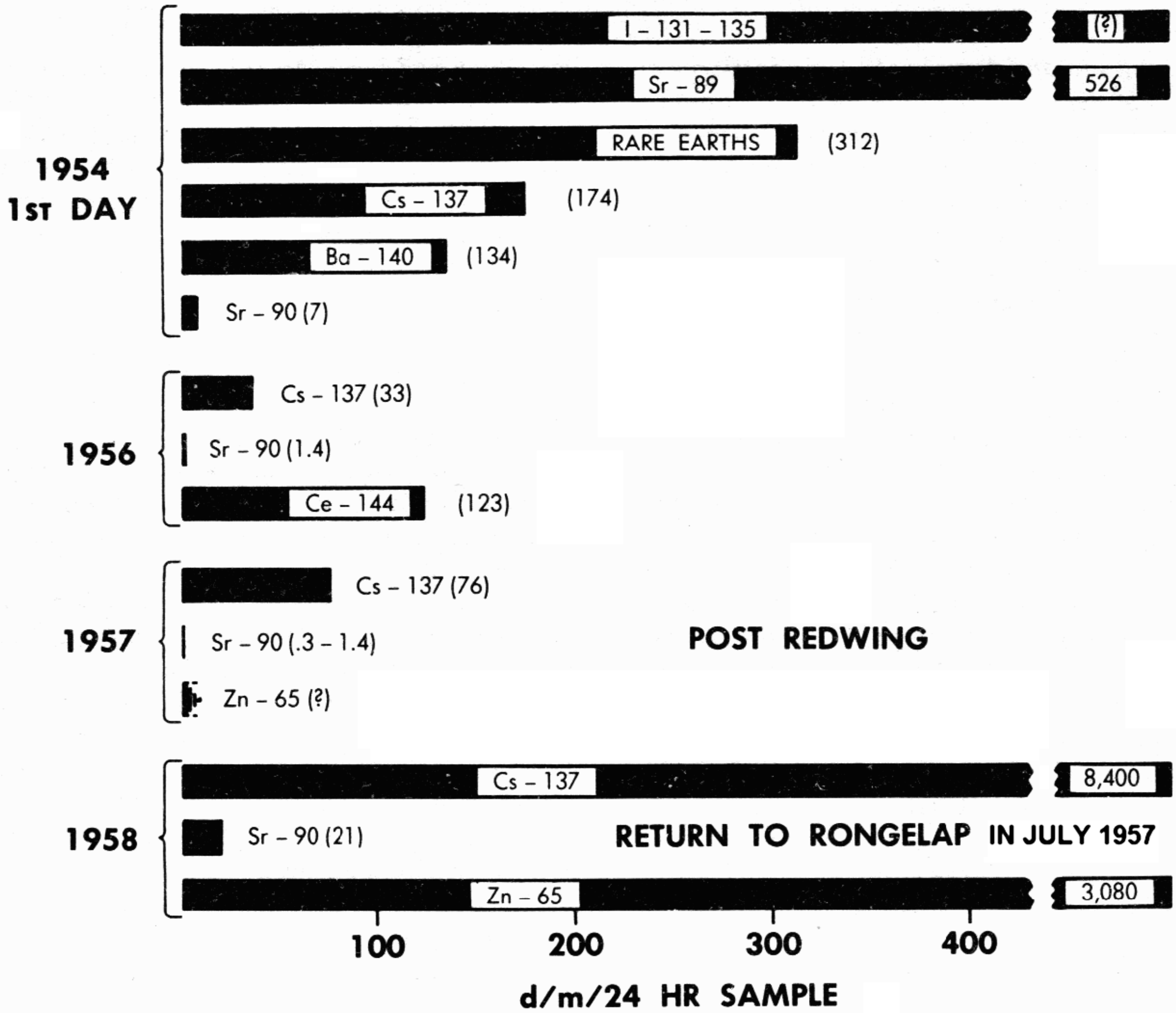


Figure 19. Urinary excretion of isotopes by Rongelap people.

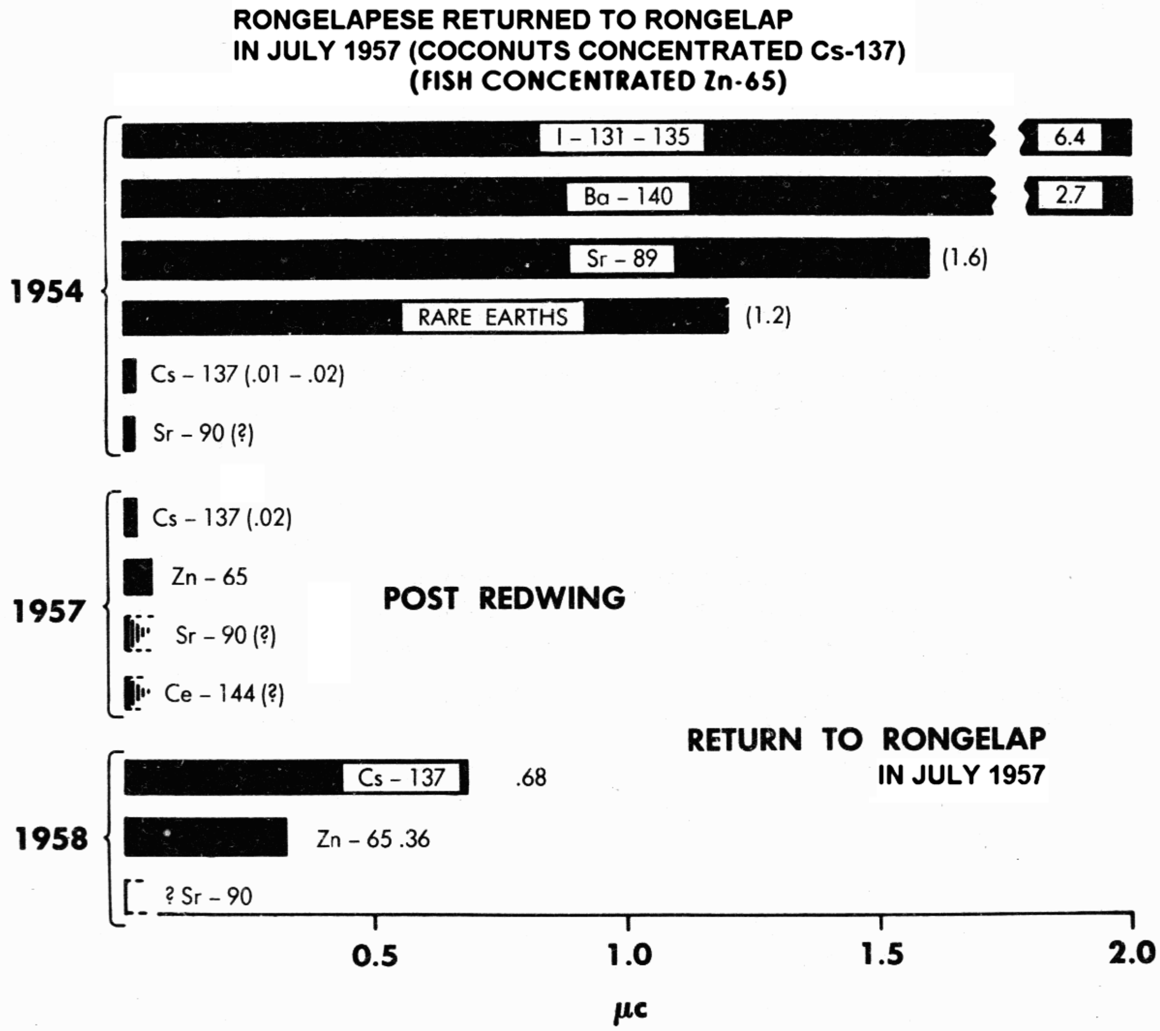


Figure 20. Estimated body burden of isotopes of Rongelap people.

DR DUNNING:

Iodine-131

1. 2 KT/mi^2 -----> 2 x 10^5 curies I^{131}/mi^2

-----> 7.7 x 10^4 μc I^{131}/M^2

2. Based on Windscale experience

1 μc I^{131}/M^2 -----> 0.1 μc I^{131}/liter of milk(5)

For one liter of this milk -----> 2 rad dose to infant's thyroid.*

For continuous consumption of milk from cows grazing on pasture until I^{131} activity essentially zero -----> 22 - 44 rad dose.*

3. Arithmetically -

(7.7 x 10^4) (22-44) -----> (1.7-3.4) x 10^6 rads total dose to thyroid of children.

4. Based on data from nuclear weapons tests, the cow's thyroid might theoretically receive a dose two orders of magnitude higher than the numan.(6)

Actually, of course, the external gamma exposure and the dose to the cow's digestive organs would guarantee its death. If milk were obtained before its death there might be enough I^{131} activity in a single pint of milk to completely destroy the infant's thyroid.

(7.7 x 10^4) (1-2 rads) -----> (7.7-15) x 10^4 rads

The short-lived isotopes of radioiodine could contribute more dose to the thyroid than does I^{131} for the first day or so, but their activity would decrease rapidly with time.(7) Milk as a food item should be avoided until the iodine activity levels dropped to acceptable limits, or canned or powdered milk (prepared before the fallout occurred) should be substituted.

5. If one assumes all contaminated milk is eliminated from the diet there remains the general I^{131} contamination of the environment including exposed foods and water.

The principal potential source of intake of the I^{131} would be leafy vegetables and other similarly exposed foods. This I^{131} contamination would be reduced by washing the foods, since the water supply would be expected to contain less I^{131} activity due to dilution factors. However, the reduction would have to be considerable since a single intake of I^{131} from one square meter of surface during the first week after the fallout occurred might produce a thyroid dose of more than 10^5 rads to the adult thyroid. It is not being postulated here that persons normally lick over a square meter of surface, but it illustrates the very heavy contamination that might exist in the environment, and that prevention of entry of significant amounts into the body would be a serious consideration.

6. Based on radiological decay only, it would require about 80 days for the I^{131} activity to decay by a factor of 1000. Even considering weathering effects it is doubtful if pasture lands would be useable by then, since doses in the order of a few hundred rads to the infant's thyroid may be carcinogenic.(8)

D. Strontium-90

1. General.

   2 KT/mi^2 -----> 200 curies Sr^{90}/mi^2

   Due to fractionation there may be 2 - 3 times less than this for the close-in areas, i.e. 67-100 curies Sr^{90}/mi^2

2. 80 mc/mi^2 -----> 8 S.U. in children (in equilibrium)* (17) or 10 mc/mi^2 ----> 1 S.U. in children. This is based on U.S. diet including milk as a major source of calcium. Use of other foods as a source of calcium would increase the Sr^{90} intake due to less discriminatory factors.(18)

3. Using 200 curies Sr^{90}/mi^2 and conversion factor

   10 mc/mi^2 -----> 1 S.U. at equilibrium.

   20,000 S.U. -----> 20 r/yr to bone marrow**

   -----> 470 r in 35 years (assuming(a) mean life of surviving population in 35 years, and a radiological decay of Sr^{90} in environment and in man).***

4. The above estimates do not consider any decontamination measures, selection of lesser contaminated foods for consumption, or use of foods from lesser contaminated areas. One may assume these factors will reduce the above estimates by whatever degree we wish to postulate the effectiveness of the factors.

* Equilibrium in children might be reached in 2 - 3 years. Equilibrium would be approached in adults only after many years and to this extent calculations overestimate the effect.

** This may be a somewhat low estimate.

***The biologically available strontium would be expected to decrease naturally with time faster than its radiological decay would indicate, therefore, the assumption used here tends to overestimate the exposure.

Carbon-14

1. Assume: 1 M.T. (total yield) $\dashrightarrow$ 2×10^{26} neutrons (Outside bomb)
$\dashrightarrow$ 4.7 Kg C^{14}

   If one-half of neutrons "lost" to ground (i.e. surface bursts),

   then $\dashrightarrow$ 2.4 kg. C^{14}/M.T.

2. 3953 M.T. (total yield) $\overset{\sim}{\dashrightarrow}$ 9.3×10^3 kg. C^{14}

3. There are two reservoirs for freshly produced C^{14}:(21)

   4.4% in reservoir A[a] with Tm of 8070 yrs.

   95.6% in reservoir A with Tm of 27.2 yrs.

4. There are 3200 kg. C^{14} normally present in reservoir A[b].

$$\frac{(9.3 \times 10^3)\ \ (4.4 \times 10^{-2})}{3200} \times 8070 \times 1.5^{(c)} = 1550 \text{ mr}$$

$$\frac{(9.3 \times 10^3)\ \ (9.6 \times 10^{-1})}{3200} \times 27.5 \times 1.5 = \underline{120 \text{ mr}}$$

Total 1670 mr or $\sim$1.7r

5. Assuming that transmutations account for roughly the same number of genetic defects as does radiation, (22) then: $\sim$3.4 r "effective" over 8000 years.

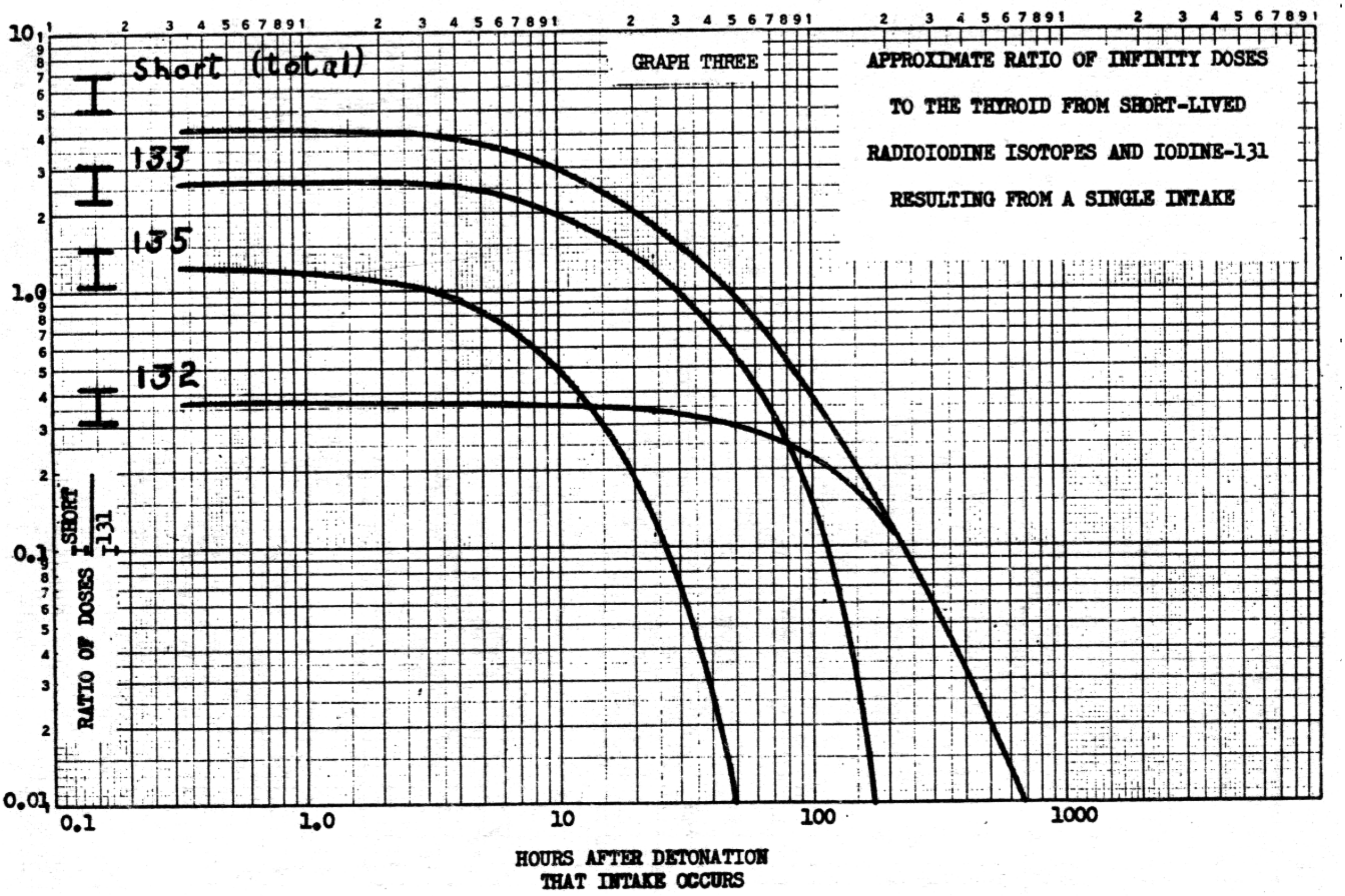
6. During the same period of time (8000 years) the dose from naturally occurring radioisotopes in the environment and from cosmic rays might amount to 800 r (assuming no change in the present rate). The effect from C^{14} would not be zero but would not constitute a problem to the same degree as other factors.

(a) The atmosphere, the land biosphere, and humus.

(b) This assumes uniform distribution over the world which may not be too greatly in error for C^{14}.

(c) Yearly dose from C^{14} present in environment.

***The biologically available strontium would be expected to decrease naturally with time faster than its radiological decay would indicate, therefore, the assumption used here tends to overestimate the exposure.



GRAPH 3

Graph 4 shows the number of microcuries of fission products ingested at times after detonation to produce 1.0 rad to the thyroid.

III. Doses to the Bones

The three principal bone-seeking isotopes of concern are Sr^{90}-Y^{90}, Sr^{89}, and Ba^{140}-La^{140}. Evaluation of these may be made in terms of amount deposited in the bones versus maximum permissible body burdens, or in rads of dose that they deliver after deposition. Since values for maximum permissible body burdens are based on the concept that these will be maintained indefinitely in the body, they are not so valid for Sr^{89} and Ba^{140}-La^{140} when considering short periods of emergency intake.

The following principal assumptions are used in calculating the doses to the bones of adults:

a. The percentages of the isotopes of Sr^{90}-Y^{90}, Sr^{89}, and Ba^{140}-La^{140} in mixed fission products are according to Hunter and Ballou.[3]

b. The percentages of intake of these isotopes that are deposited in the bones, the energies of emissions, and their effective half lives are according to reference five—except for Sr^{90} where a 27.7 year radiological half life is used here.

c. The mass of the bones is 7,000 grams.

The method of calculation of doses to the bones is illustrated by computing the dose from Sr^{89} from the intake of 27 microcuries (See IV Discussion below) of mixed fission products on the 120th hour. Similar calculations were made for Sr^{90}-Y^{90} and Ba^{140}-La^{140} and then the three doses were added for each intake of fallout material.

Step 1. Determine the Sr^{89} to reach the bone.

According to reference 4:

The Sr^{89} content in mixed fission products on the 120th hour is 1.6%.

According to reference 5:

The intake of Sr^{89} to reach to the bones is 25%.

Therefore:

(27) $(0.016)(0.25) = 0.108$, to the bone.

Step 2. Determine the dose rate to the bones.

With an assumed effective energy of 0.55 Mev (reference 5):

$$\frac{(0.108)(2.2 \times 10^6)(60 \times 24)(1.6 \times 10^6)(0.55)}{(100)(7{,}000)}$$

$$= 4.3 \times 10^{-4} \text{ rads/day } \textit{or } 0.43 \text{ millirads/day}$$

Step 3. Determine total dose.

D total $= (R/\lambda e)$

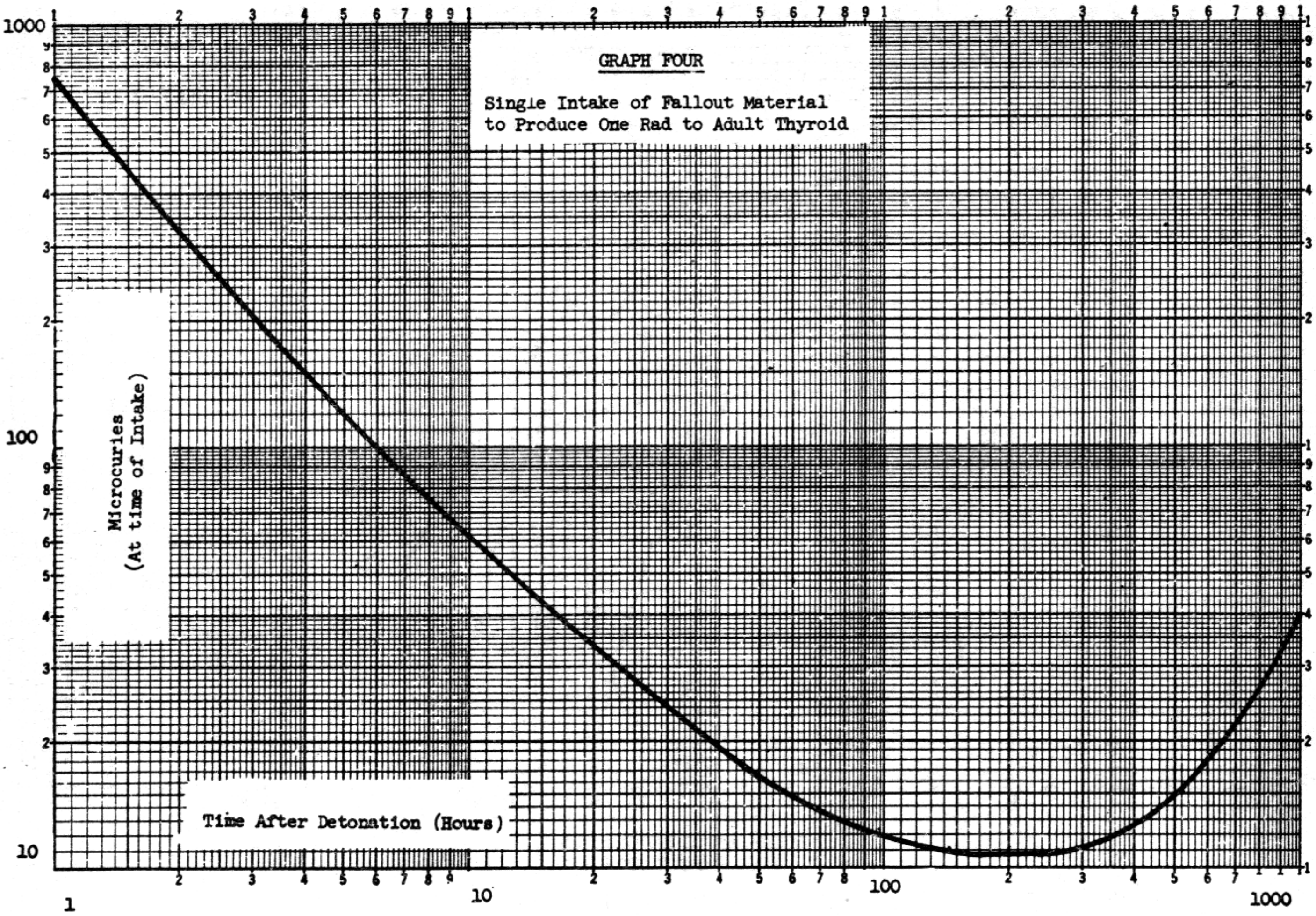
where: R = initial dose rate

λe = effective decay constant

D total $= (0.43/0.0133) \cong 32$ millirads*

* The relative total doses from these isotopes are as follows:

Time of intake	Sr^{90}	Sr^{89}	Ba^{140} – La^{140}
24th hour	0.6	1.00	0.6
20th day	1.00	1.00	0.3



GRAPH 4

IV. Discussion

A. Solubility

The solubility of fallout material varies, depending among other factors upon the surface over which the detonation occurred. The fallout material collected in soil samples at the Nevada Test Site has been quite insoluble, i.e. only a few per cent in distilled water and roughly 20–30 per cent in 0.1 N HCl. However, it would be expected that the activity actually present in drinking water supplies would be principally in soluble form. The water collected from a well and a cistern on the Island of Rongelap (Table III) about 21 months after the March 1, 1954 fallout, was found to have about 80 per cent of the activity in the filtrate, but there was an undetermined amount that settled to the bottom. Other data suggest the material to have been about 10–20 per cent soluble in water.

In the event contaminated food is ingested it is possible that the total activity—soluble and insoluble—may find its way into the gastrointestinal tract since at times immediately following a fallout most of this activity probably would come from the surface contamination rather than the soil-plant-animal cycle. There may then follow some solubilizing in the acid stomach with subsequent removal from the tract before reaching the lower large intestine.

TABLE III

Concentrations in Water on Islands in the Pacific and Estimated Gamma Dose Rates at D + 1, Three Feet Above Ground

Date	Location	Gross Fission Product Activity (*d/m*/ml)
	Rongelap Island (3.5 roentgens per hour)	
D + 2	Cistern	~50,000–75,000
D + 34	"	~5,500
D + 34	Openwell	~2,000
D + 300	Cistern	~3
D + 330	"	~4
D + 600	"	~5.5
D + 600	Openwell	~0.5
D + 600	Cistern (With collapsed roof)	~1.3
	Kabelle Island (19 roentgens per hour)	
D + 330	Ground water	~48
	Eniwetok Island (8.5 roentgens per hour)	
D + 330	Cistern	~25
	Enibuk Island (1.3 roentgens per hour)	
D + 600	Standing water from can, drum, etc.	~1.4

Representative HOLIFIELD. Dr. Stanton H. Cohn will present testimony on the evaluation of the hazards from inhaled radioactive fallout. Dr. Cohn is presently with the Medical Physics Division, Medical Research Center, Brookhaven National Laboratory. He is a member of the Subcommittee on Inhalation Hazards of the Pathological Effects of the Atomic Energy Radiation Committee of the National Academy of Sciences. He was a member of the U.S. Naval Medical Team which provided emergency medical treatment to the Marshallese accidentally exposed to fallout from operations in 1954. He studied the internal radioactive contamination of the exposed Marshallese. He was also a member of the AEC medical team which made the 5-year medical survey of the Marshall Islands in 1959 and studied the internal radioactive contamination by measuring body burdens of various fission products of 250 Marshallese using a whole body gamma scintillation counter. He participated in the direction of the study of the residual contamination of plants and animals of the Marshall Islands in two surveys in 1955 and 1956.

TESTIMONY OF DR. STANTON COHN,[1] BROOKHAVEN NATIONAL LABORATORY

[1] I. Experience: Scientist, Medical Physics Division, 1958 to present, Medical Research Center, Brookhaven National Laboratory, Upton, Long Island, N.Y. Head, Internal Toxicity Branch, 1950–58, Biomedical Division, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif. Research assistant, 1949–50, Crocker Radiation Laboratory, University of California, Berkeley, Calif. Biochemist, biomedical division, 1946–49, Argonne National Laboratory, University of Chicago, Chicago, Ill. Biochemist, laboratory of the 203d General Hospital, Paris, France, 1943–46, U.S. Army. Chemist, explosives, 1942–43, Kankakee Ordnance Works, Joliet, Ill., and Lake Ontario Ordnance Works, Niagara Falls, N.Y.

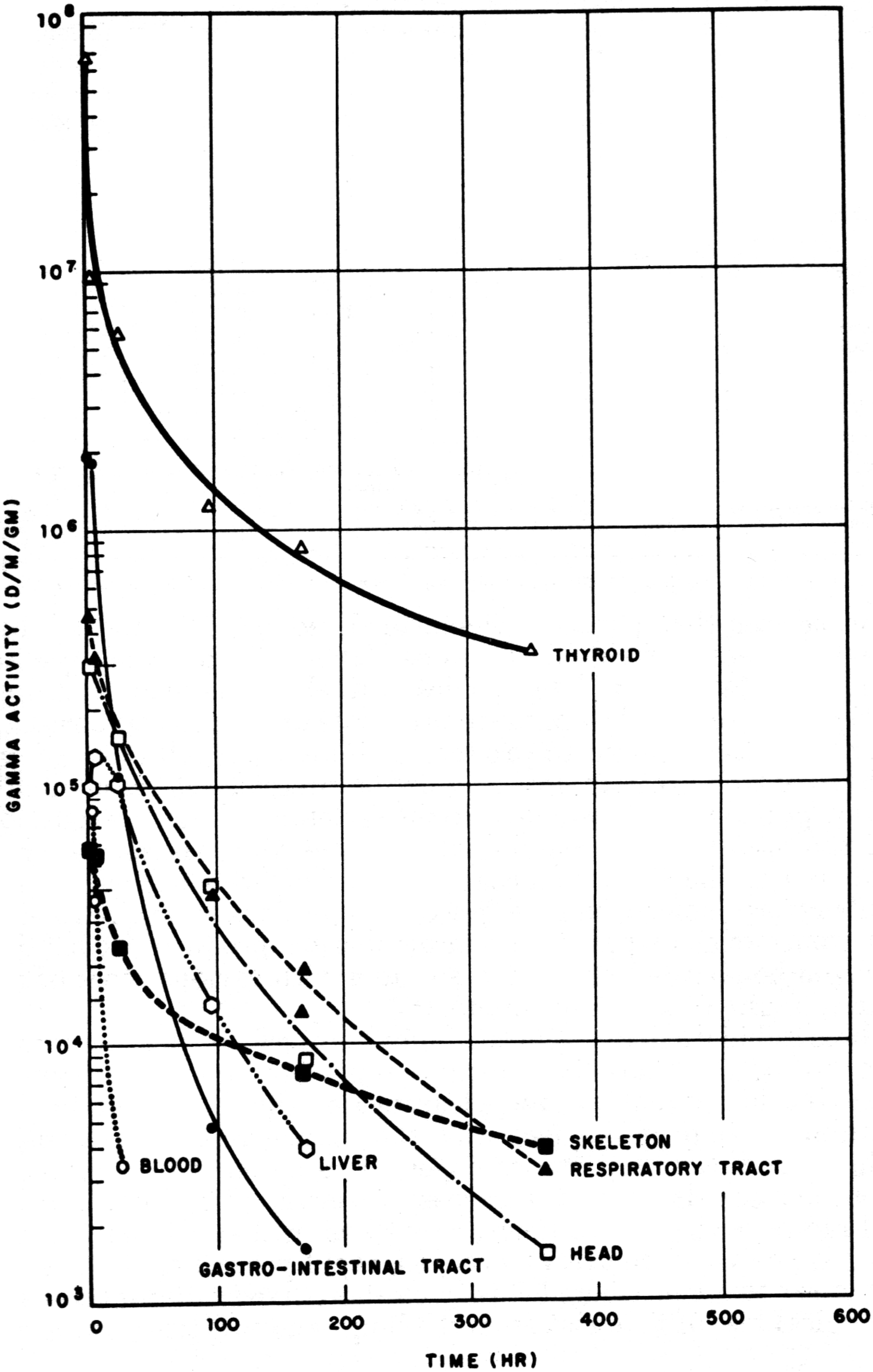
II. Education: University of California, Berkeley, Calif., 1952, Ph. D., physiology-radiobiology (Dr. Hardin Jones and Dr. D. H. Copp). University of Chicago, Chicago, Ill., 1949, S.M., physiology (Dr. Franklin McLean); 1946, S.B., Biochemistry.

III. Additional qualifications: Member of the Subcommittee on Inhalation Hazards of the Pathological Effects of Atomic Radiation Committee, National Academy of Sciences, 1956 to present. Member of the U.S. Navy medical team which provided emergency medical treatment for the Marshall Islanders accidentally exposed to fallout from Operation Castle, March 1954. Studied the internal radioactive contamination of the exposed Marshallese. Also member of the AEC medical team which made the 5-year medical survey of the Marshall Islands in 1959. Studied the internal radioactive contamination by measuring body burdens of 250 Marshallese using a whole body gamma scintillation counter. Participated in the direction of the study of the residual contamination of plants and animals of the Marshall Islands in two field surveys, 1955 and 1956. Member of the Advisory Committee on Civil Defense, 1958.

IV. Scientific Societies, memberships: Radiation Research Society, American Physiological Society.

There is no question that radiation from internal sources can produce lung cancer, but it is not as yet possible to equate the changes produced with given levels of radiation dose. The best estimate of the external dose required to produce pulmonary fibrosis and pneumonitis lies in the range of 800 to 2000 rads, with a mean dose of about 1,000 rads. The induction of pulmonary cancer from radioactive material in experimental animals requires a dose of about the same order. The smallest dose to the lung which produced malignant tumors in mice was reported as 115 rad, following administration of 0.003 μc $Pu^{239}O_2$, and 300 rads after administration of 0.15 μc $Ru^{106}O_2$. However, other studies with mice have indicated that 2,000 rad was the threshold dose for lung tumor formation. Actually, almost all of these studies utilize intra-tracheal administration of the material for experimental ease. It is difficult to compare such an exposure to one deriving from true inhalation.

FIGURE 7



FROM: STANTON H. COHN, "RADIOTOXICITY RESULTING FROM EXPOSURE TO FALLOUT SIMULANT," REPORT USNRDL—TR—118 (1957), FIG. 5.

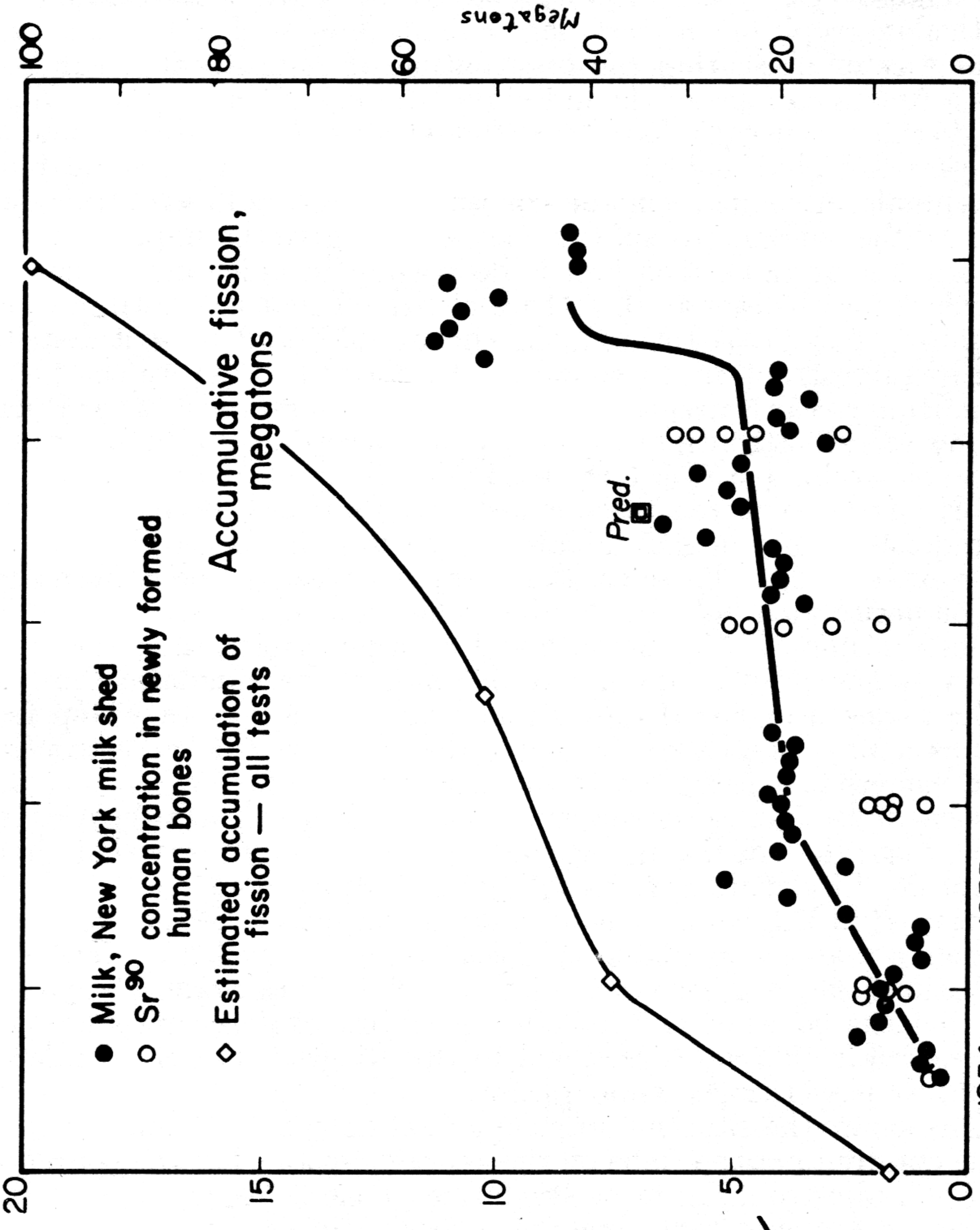
UPTAKE & RETENTION BY MICE OF A SIMULANT OF FALLOUT

PRODUCED BY A LAND BASED NUCLEAR DETONATION.

(MICE WERE EXPOSED TO 2-DAY OLD FALLOUT.)

92 fission megatons of tests to end 1958
gave a mean of 10 $\mu\mu c$ Sr^{90}/gm Calcium
$\Rightarrow$ 28 mR/year to bone in the
Northern Temperate Zone.

FIGURE II



($\mu\mu c$ Sr^{90}/gram of bone calcium)
Sunshine or Strontium Units (S.U.s)
Calcium = 1/7th of bone mass.
1 $\mu\mu c$ Sr^{90}/gm of Calcium in bone $\equiv$ 2.8 mR/year

Table 1

Area	Location	Sr90 Activity (0 - 1" Depth) mc/sq mi	μμc/g Ca
Date of Collection, August, 1958			
Cultivated Agricultural Areas			
Moapa, Nevada	7.7 mi NW	16.3	2.5
St. George, Utah	1 mi SE	14.4	4.5
Enterprise, Utah	0.7 mi N	7.46	8.6
Virgin Undisturbed Area, Fallout Midline Locations			
Moapa, Nevada	8 mi N	142	38.3
St. George, Utah	5 mi N	45.6	406
Enterprise, Utah	9 mi N	41.2	51.2

Effect of plowing on concentration of Nevada bomb test fallout in soil

SOIL DECONTAMINATION:

The addition of lime ($CaCO_3$) and gypsum ($CaSO_4$) to acidic soils low in native Ca reduced Sr^{90} uptake by plants. Greatest inhibition occurred at treatment levels equivalent to from 2 to 5 tons per acre. At these levels $CaCO_3$ reduced Sr^{90} uptake about 60 per cent; $CaSO_4$ caused an 80 per cent reduction. These Ca amendments to the soil had little or no influence on the uptake of Sr^{90} from neutral and alkaline soils.

The uptake of Cs^{137} occurring as a contaminant increased as the K concentration in the soil was reduced by prolonged cropping. The addition of K to contaminated soils low in potassium content reduced the uptake of Cs^{137} by plants. (Potassium chloride should have been applied to Rongelap coconuts in 1959 to reduce cesium-137 in diet, instead of evacuation again.)

These radioecological studies have clearly revealed that (1) biological effect (or hazard) cannot be realistically assessed on the basis of measurement of only the gamma radiation field. Fission products from radioactive debris produced by man can be assimilated by animals with the maximum degree of accumulation not necessarily near the source of the nuclear reaction. Further, within a distance of 400 miles from the Nevada Test Site, the plant foliage is a selective particle collector. There has been no significant accumulation of activity through the root system. (2) Biological availability of fallout debris is strongly influenced by the conditions of contamination and by the physical and chemical nature of the contaminating material and its interaction with environmental factors. (3) Within 200 miles from the Nevada Test Site Sr^{89} and Sr^{90} are estimated to be less than 10 per cent of the total theoretical Sr^{89} and Sr^{90} generated by all detonations at the Nevada Test Site since the Ranger Test Series.

FRACTIONATION OF SR89/90 IN LOCAL FALLOUT.

STATEMENT OF HERMAN KAHN,[1] CENTER OF INTERNATIONAL STUDIES, PRINCETON UNIVERSITY

Mr. KAHN. I will do my best.

Representative HOSMER. I think, Mr. Chairman, that Mr. Kahn and the people who have worked with him have given this subject the closest scrutiny that it has ever been given. I think we are fortunate indeed to have him before us.

Mr. KAHN. Thank you very much.

Representative HOLIFIELD. I notice that you have been here every day. You have seen a congressional committee in action over a long period of time now. I think you have a concept now of the laborious method by which we put things on record.

[1] Undergraduate work at UCLA. Graduate work at California Institute of Technology. With Rand Corp. for 10 years, November 1958 to present. On leave of absence since January 1959 and now with Center of International Study, Princeton University. Was a consultant to the Gaither Committee; Scientific Advisory Board of the Air Force; Technical Advisory Board, AEC; Office of Civil Defense Mobilization.

This is of some real interest; before World War II, for example, many of the staffs engaged in estimating the effects of bombing overestimated by large amounts. This was one of the main reasons that at the Munich Conference and earlier occasions the British and the French chose appeasement to standing firm or fighting. Incidentally, these staff calculations were more lurid than the worst imaginations of fiction.

Let me give an example. In 1956, there was a revolution in Hungary which the Russians suppressed. There was at that time much pressure on the United States to intervene in that revolution to support the Hungarians. I myself felt rather strongly we should do something. However, I wish to ask the following question: If we had intervened, would the Russians have accepted that intervention, say in 1956? Would they accept it in 1960? These are different situations. It is possible that we did more than not intervene. There are rumors—I do not know if they are true or not—that we broadcast to the East Germans and the Poles not to rock the boat, that American aid was not on the way if they did. There are reasons for worrying about a satellite revolt spreading and, if we had intervened, it is quite clear that there would very likely have been a widespread satellite revolt. Particularly if the Russians did nothing, if they just let us get away with it. After all, some of the satellites revolted without any American intervention.

A satellite revolt is a very big thing to the Russians, and they might not be willing to stand for it. Much more important, the Russians are greatly concerned with internal stability.

I would like to emphasize: Britain declared war on Germany in 1914. Britain declared war on Germany in 1939. If they had not been able to declare war in either of those 2 years, they would have had to let the Germans do whatever they wanted to do.

However, it may well be, though, that we will face problems in the near future which are just not solvable by the techniques we have used in the past. In fact, that is true today to some extent. And it may well be that we should start on this new world right now. But it is a mistake to say that the new world has arrived today. It does not seem to be true.

I have a book with me today which I recommend to those who want to exaggerate the impact of thermonuclear war. It is called "Munich: Prologue to Tragedy," by Wheeler Bennet. Among other things Wheeler Bennet discusses why Chamberlain and Daladier folded. When they returned from Munich they were cheered by their people in Paris and London, because war had been averted. Over that weekend some people began to understand that war had been averted by a sellout of the worst sort. And on Monday some few were prepared to criticize. But if you read the debate, you noticed something very significant. The people who criticized Chamberlain and Daladier, with a couple of exceptions, did not criticize them for not going to war; they said, "Hitler was bluffing, and you should have stood your ground."

As far as we can tell, Hitler was not bluffing. The men who were in the room with him could see he was not bluffing. It was easy for the people back home to say he was bluffing, but not for the men who had the decision to make. The German people did not want war. The German Army did not want war. They literally threatened to have a military revolution. But Hitler seems to have been willing to have a war if he couldn't have his way.

We may be asked that same question. If the other man is not bluffing, and he may not be, then we have to ask ourselves, "Are we willing to fight or are we not? Do we have an alternative to peace?" It is just that simple.

It turns out that the chain which brings Sr^{90} into the human body from the fallout to the grass, to the cow, to the milk, to the intestines, to the bone, discriminates against strontium 90 versus calcium.

But from our point of view that damage, though acceptable over 10,000 years, is much less acceptable if it is taken in, say, 20 years. If carbon 14 had a lifetime of only 20 years, you would be much less willing to face the possibility of a war and more willing to appease. And if it was a really big war you could not face it, because you would be getting thousands of roentgens in one generation rather than 50. SPECIFIC ACTIVITY $\propto$ 1/(HALF LIFE)

Symposium

The Shorter-Term Biological Hazards of a Fallout Field

Washington, D. C. • December 12–14, 1956

Edited by

Gordon M. Dunning

Division of Biology and Medicine

Atomic Energy Commission

John A. Hilcken

Armed Forces Special Weapons Project

Department of Defense

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SOIL ERODIBILITY AS A FUNCTION OF PARTICLE SIZE

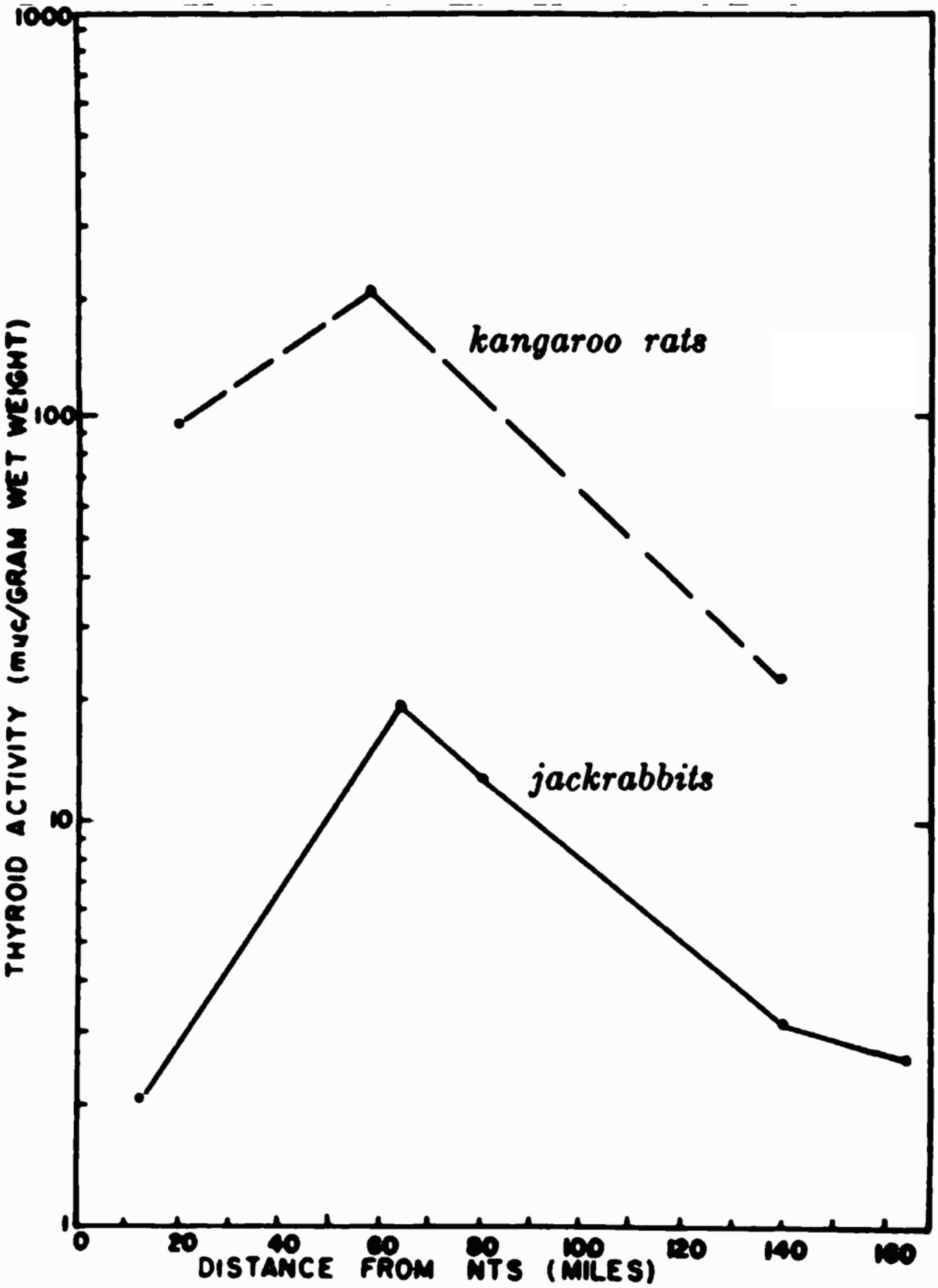
Diameter (microns)	Relative erodibility
Less than 20	Non-erodible except at wind speeds greater than 50 mph, 6 inches above ground.
0 - 50	Difficult to erode.
50 - 500	Highly erodible.
500 - 1000	Difficult to erode.
More than 1000	Non-erodible except at wind speeds greater than 50 mph, 6 inches above ground.

K. M. Nagler, U. S. Weather Bureau

Mr. Nagler. This concept that large particles are more easily blown away than smaller ones seems unlikely at first thought, but it has been verified experimentally. The explanation, I believe, lies in the way that the wind speed decreases very close to the surface over which it passes. With moderate wind speeds at a few inches above ground, the force of the wind is still strong enough 100 or 200 microns above the surface to move a particle which is large enough to extend into that layer, but it is normally so much weaker just above the surface that it is unable to move a 20 micron particle.

Mr. Nagler. I can cite an example of this. We drove in very close to the remains of one tower—that from the explosion on May 5, 1955—just a few days after the test. The levels of radioactivity were rather low on the asphalt pad almost underneath the tower itself. There had been rather strong winds.

LINDBERG, R. G., et al. The Factors Influencing the Biological Fate and Persistence of Radioactive Fallout. Operation Teapot, Project 37.1, Report ITR–1177, 1955.



The relationship of distance to the occurrence of radioiodine in the thyroids of kangaroo rats contaminated by radioactive fallout, and to the occurrence of radioiodine in the thyroids of jackrabbits contaminated by a different fallout

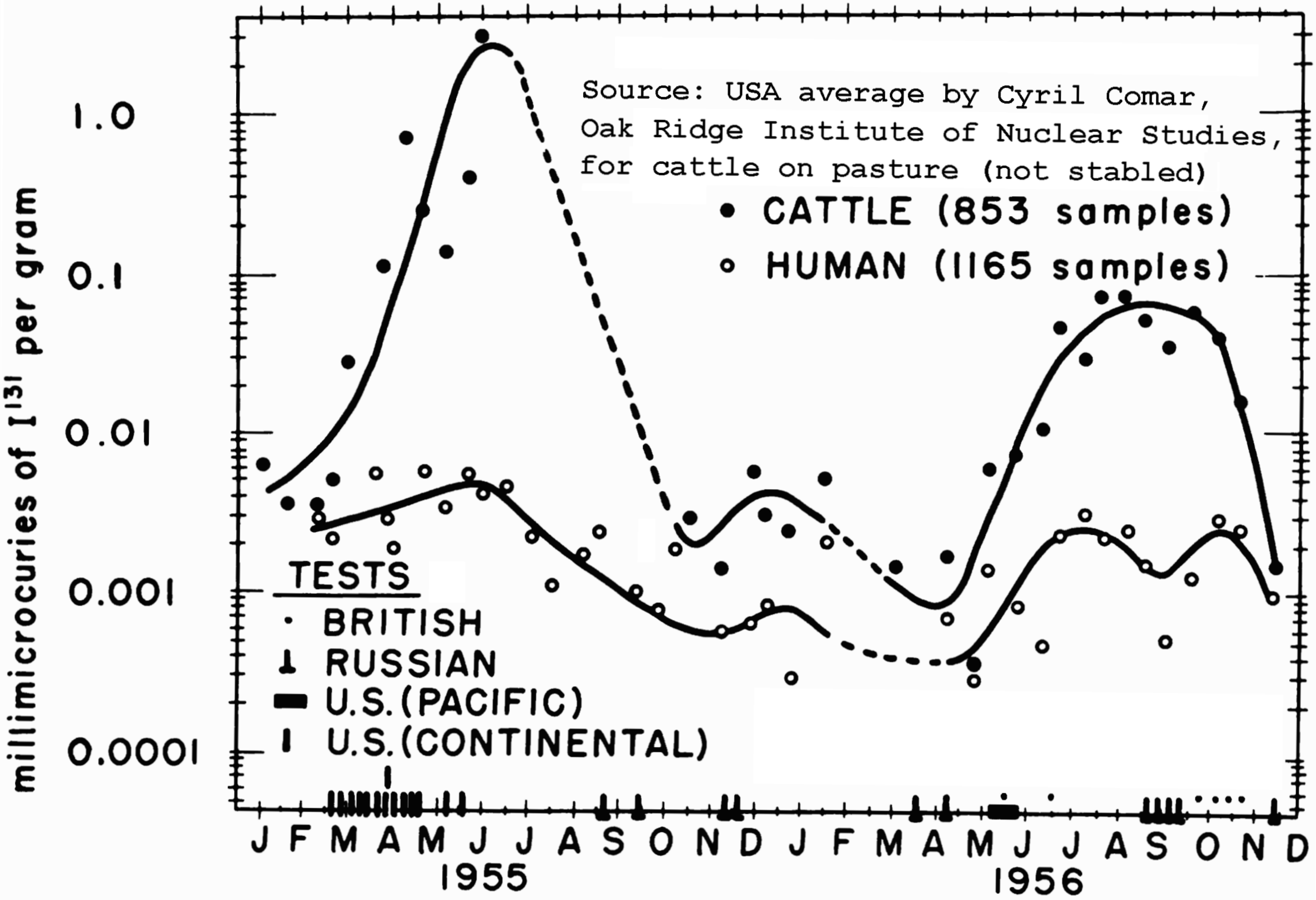


FIGURE 2.—*Cattle (853 samples), and human (1,165 samples) thyroid levels of I-131.*

WT-617

Copy No. [redacted] TA

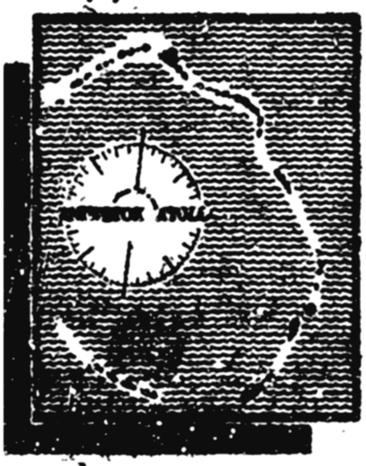
Operation IVY

PACIFIC PROVING GROUNDS

November 1952

Project 5.4b

FALL-OUT AND CLOUD-PARTICLE STUDIES



JOINT TASK FORCE 132

CHAPTER 2

BACKGROUND

2.1 INTRODUCTION

In past atomic detonations the results obtained from projects concerned with fall-out have not always been consistent. Fall-out results have been influenced by methods of collection and analysis, weather conditions, type and height of shot, and yields of the devices. However, results from past operations do show some trends which are of interest in this study.

2.2 SIGNIFICANCE OF RADIOACTIVITY AND PARTICLE SIZE

Radioactive fall-out can be both an external and an internal hazard to personnel.

External radiation can cause injury to body tissues of living organisms in the area of fall-out if the tissues are exposed to a large amount of radiation in a short time. One hundred roentgens (in a matter of minutes) has been suggested by the USAF Air Surgeon as a lifetime radiation dose which a soldier might be given in time of war.[1] This dose might produce some temporary blood-cell changes and a case of radiation sickness, but no permanent injury would be incurred by the soldier. No evacuation would be contemplated, and there should be no reduction in combat effectiveness.[2]

The internal hazard due to an aerosol depends, to a great extent, on the size of the radioactive particles inhaled. The nose will filter out almost all particles over 10 μ in diameter and about 95 per cent of all particles exceeding 5 μ. Particles of 0.5 to 5 μ are most likely to be retained in the lungs, or they may be transferred to the blood stream and the lymphatic system.[3,4] Internal contamination will also depend on the length of exposure to radioactive particles and the respirator rate. Particles of any size may be taken into the mouth, thus constituting an internal hazard.

In Operation Jangle Project 2.7, lung sections of dogs and sheep were examined.[4] Many crystalline particles 2 μ and under were found. The few radioactive particles found were in clusters and were alpha, alpha and beta, or beta emitters. Most particles either were never radioactive or had decayed to the point where no radioactivity could be detected at the time of examination. It is possible that the radioactive material had dissolved off the inert particles and had been redistributed. Lung tissues contained significant amounts of radioactivity as determined by counting techniques. The total internal dose was less than 1 per cent of the external dose from both shots, and the animals did not acquire significant amounts of radioactivity by inhalation or ingestion.

Radioactive fall-out may contaminate equipment to the point where it cannot be used safely for a period of time. Particles in the micron and submicron ranges are more difficult to remove mechanically than are larger particles. If these particles are radioactive, they can

present a serious contamination problem. Very large particles are more easily detected, measured, and removed by brushing and hosing.

2.3 PARTICLE SIZE, ACTIVITY, AND DISTANCE

Fall-out dust picked up on the USS Independence after Operation Crossroads Able shot indicated that the specific activity became larger as the particle radius decreased from 550 to 10 μ.[5] About 20 per cent of the total activity in the dust of the ventilation system of the USS Crittenden after Baker shot was in the 44- to 210-μ range; 51 per cent of the total activity in the same dust sample was 10 μ or less.[6] Both ships were approximately 600 yards from their respective ground zeros.

A moderate amount of activity[7] (up to 24 per cent) was found in particles 20 μ or smaller from Greenhouse Dog shot fall-out by Project 6.4. Greenhouse Easy shot samples indicated that greater than 92 per cent of the activity in the samples was associated with particles 20 μ or larger.

Estimates by the Greenhouse Radiological Safety Unit (Rad-Safe)[8] of the size of Dog shot radioactive-fall-out particles were made by comparison with red blood cells 7 to 8 μ in size. Thus examined, particles appeared to be 50 to 150 μ in diameter. Studies of mechanically separated particles indicated that fall-out during the first 6 hr after Dog shot was no smaller than 20 to 25 μ.

On Operation Jangle, Project 2.5a-1 sampled gross aerosol 7 ft above the ground with cascade impactors.[9] In an examination of the slides for particle-size distribution, no particles were found to be larger than 40 μ; the impactors may have shattered the larger particles. The tendency to smaller particle sizes in the aerosol at increasing distances from ground zero was observed after both shots. The underground-shot gross aerosol initially possessed a distribution containing slightly larger particles [number median diameter (NMD) 1.5 μ] than the surface shot (NMD, 1 μ). The underground-shot particles fell out faster than the surface-shot particles, and 50,000 ft from ground zero gross aerosol from both shots had an NMD distribution of less than 0.1 μ. No over-all correlation of activity with particle size could be made with the cascade impactors or any other sampling instrument used on this project. However, correlations were made with the data from some individual stations, showing the percentage of active particles from the surface-shot fall-out to be 0.01 per cent for 1-μ particles, whereas the percentage of active particles for underground fall-out particles of 100 μ was found to be 20 per cent.

Some Jangle underground-shot gross-fall-out samples were radioautographed.[10] Seventeen to eighteen per cent of all counted particles above 149 μ were radioactive, whereas only 0.9 to 4.2 per cent of the smaller size fractions were radioactive. These particles were collected 2000 ft northeast of ground zero.

Project 2.5a-2 found the gross-particle NMD for the underground shot to be 0.2 μ by electron-microscope analysis.[11] The radioactive-particle NMD was 1.4 μ. However, more than 93 per cent of the activity from both shots was associated with particles 20 μ or larger. Over-all area relations of activity with distance were not pronounced on the surface-shot fall-out. However, the underground-shot activity varied directly with distance from ground zero (within the limits of the experiment). For both shots the specific activity increased with distance.

The bulk of all radioactive dust collected at distances greater than 200 miles from ground zero was found to be less than 5 μ in diameter.[12]

2.4 RATE OF FALL-OUT

During the Sandstone tests[7] a secondary fall-out was reported from Kwajalein on Yoke + 1 day, 36 hr after the explosion and 400 miles southeast of Eniwetok. The fall-out occurred as radioactive rain that fell intermittently during a 10-hr period. The maximum activity was about 6 to 10 mr/hr.

On Operation Greenhouse[7] fall-out occurred over the southern half of the Atoll, starting about 3 hr after Dog shot and reaching a peak about 6 hr later. Activities ranged from 30 mr/hr at Eniwetok to 250 mr/hr at Rigili, from 1100 to 1700 hr on D-day. Fall-out from Easy shot was concentrated in the northern third of the Atoll. Activities ranged from 120 mr/hr at Piiraai to 3 r/hr at Bogallua on E-day, from 0700 to 1400 hr. A small secondary fall-out occurred on Parry and Eniwetok on E + 1.

Fall-out from the Jangle surface shot[11] was collected for 2 hr along a long narrow swath N10°E from ground zero. The first fall-out reached a station 14,000 ft from ground zero in 8 min. A second wave reached this section 60 to 100 min later. The first wave also reached a 20,000-ft station in 10 min; therefore the initial fall-out traveled approximately 20 to 23 mph to the two stations from ground zero. However, the surface wind actually traveled 2 mph; so the fall-out must have been carried by higher speed upper-altitude winds. Heavy fall-out from the Jangle underground shot covered a wider area, generally north-northeast from ground zero. There were three waves of fall-out recorded at stations 2000 and 3000 ft north of ground zero during the first 10 min after the detonation. At 14,000 and 20,000 ft north of ground zero, there was one pronounced wave during the first 15 min after shot time. Surface-wind velocity was only about 4.5 mph, whereas it was 21 mph at the top of the underground-shot cloud. There was a series of secondary fall-outs 30 to 100 min after the shot at the more distant stations. Individual sample activities from both shots were of the order of 10^8 counts/min during these peaks.

2.5 PHYSICAL CHARACTERISTICS OF RADIOACTIVE PARTICLES

Most of the Greenhouse radioactive particles were in the form of black spheres, which occurred as individual particles, particles adhering to coral grains, and clusters of spheres with transparent granules. The size of most of the particles ranged from 2 to 500 μ.

The Jangle radioactive particles were observed to be, generally, glassy spheres and grains.[11] Their elemental composition was the same as the inert soil, except that boron and carbon were missing. The Jangle fall-out was of a heterogeneous nature.

2.6 DECAY SLOPES

Decay slopes of a limited number of Operation Jangle underground-fall-out fractions, collected at distances from 2000 to 6000 ft northwest, north, or northeast from ground zero, varied from −0.45 to −1.44, with most of the slopes in the range of −1.1 to −1.3 between H + 1000 to H + 2000 hr.[8] It appears that the absolute values of the decay slopes increase as particle diameter decreases. Also, within the limitations of the data, the absolute value of the decay slopes appears to be relatively highest on the northeast leg from ground zero. The slopes decrease on the north leg and decrease further on the northwest leg. However, another investigator[13] found that decay slopes did not vary much for particles larger than about 300 μ. It is not known where these samples were collected in the test area.

2.7 RADIOCHEMISTRY

Previous radiochemical studies on samples collected from nuclear detonations have indicated a variation in fission-product activities with particle size.[7,9,14]

2.8 SUMMARY

An extensive review of the fall-out data given in the previous sections, including information on collecting apparatus, particle-size distribution of fall-out and aerosol near the surface,

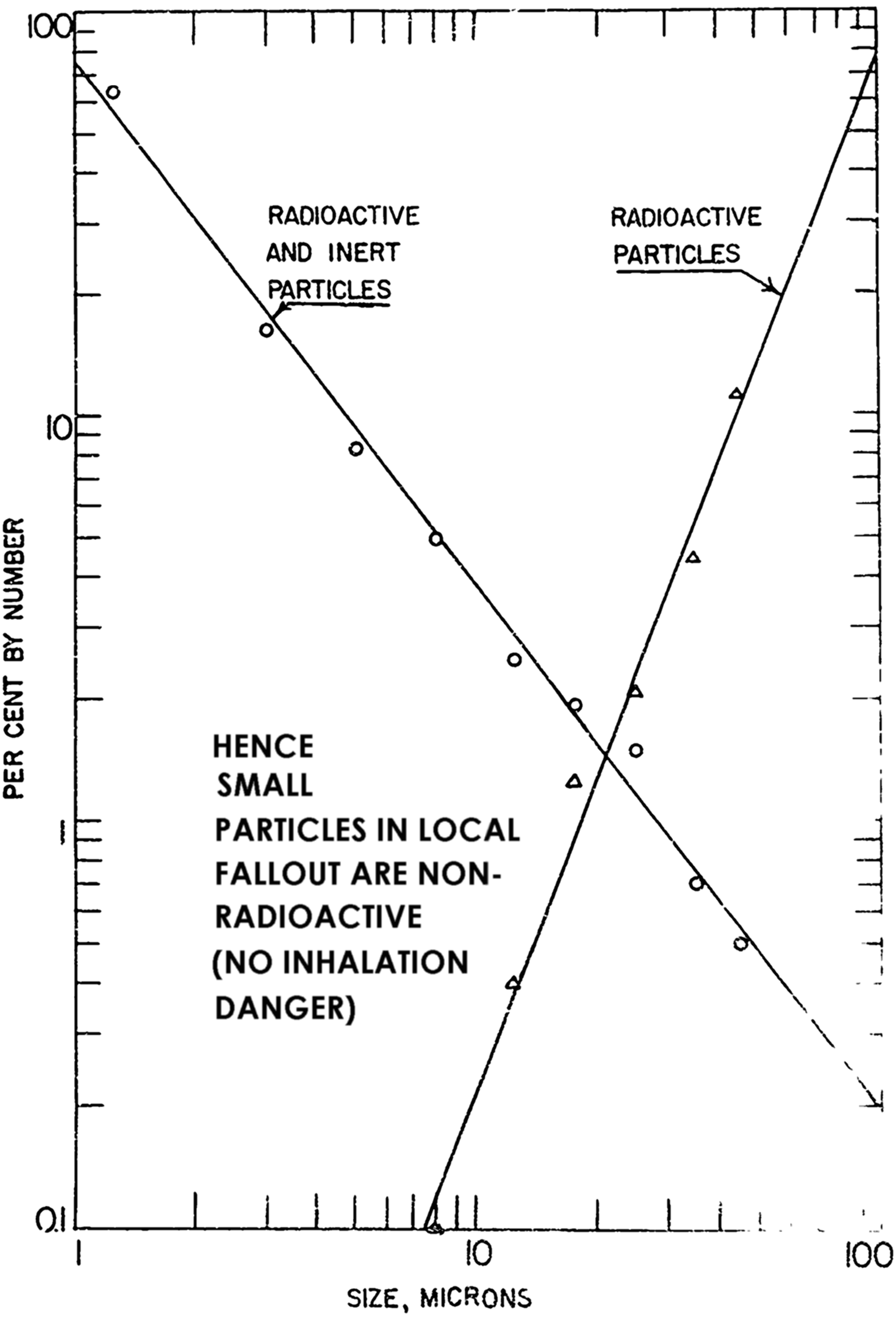


Fig. 6.2—Average percentage of total particles counted in each size range and average percentage of radioactive particles in each size range, Mike shot.

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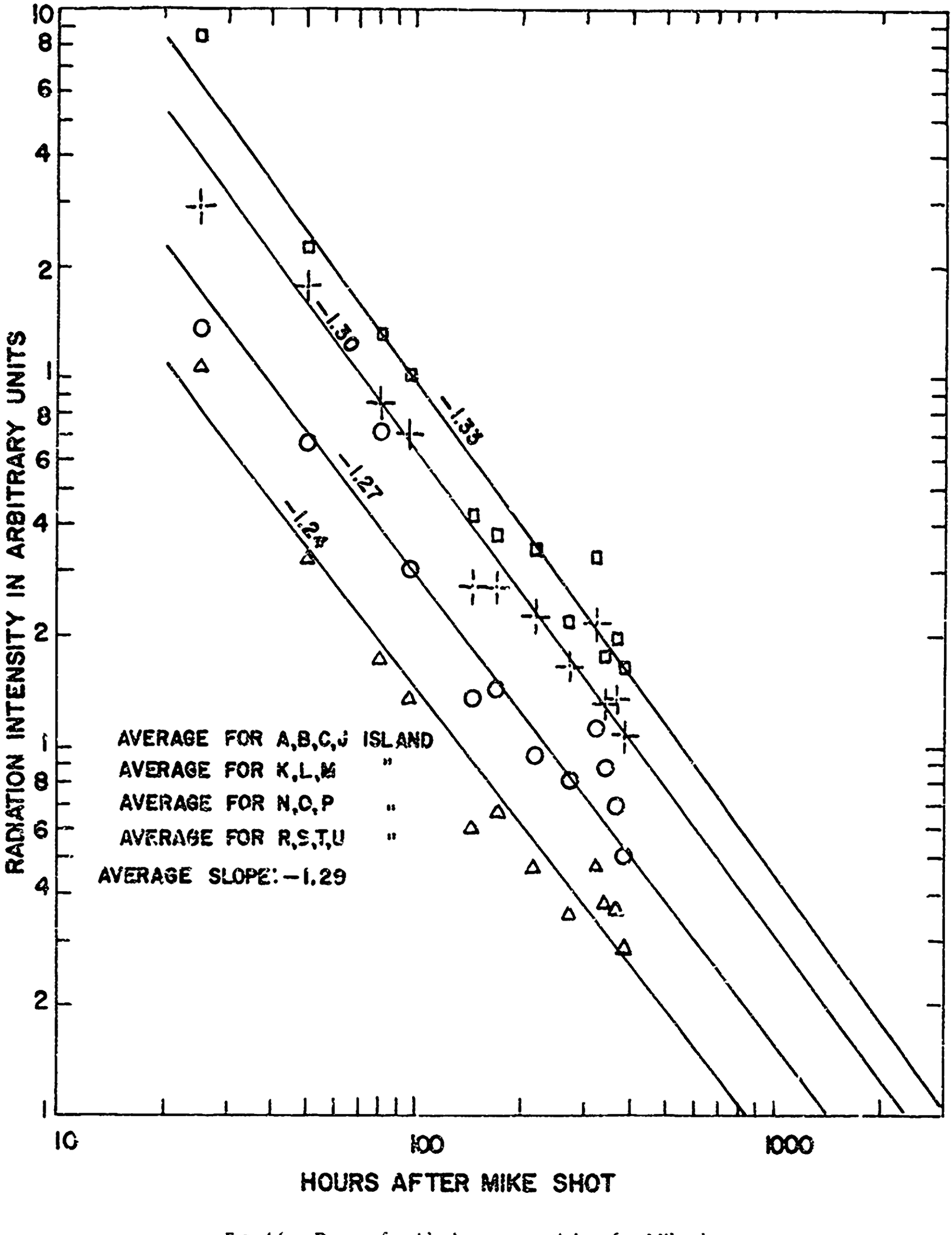


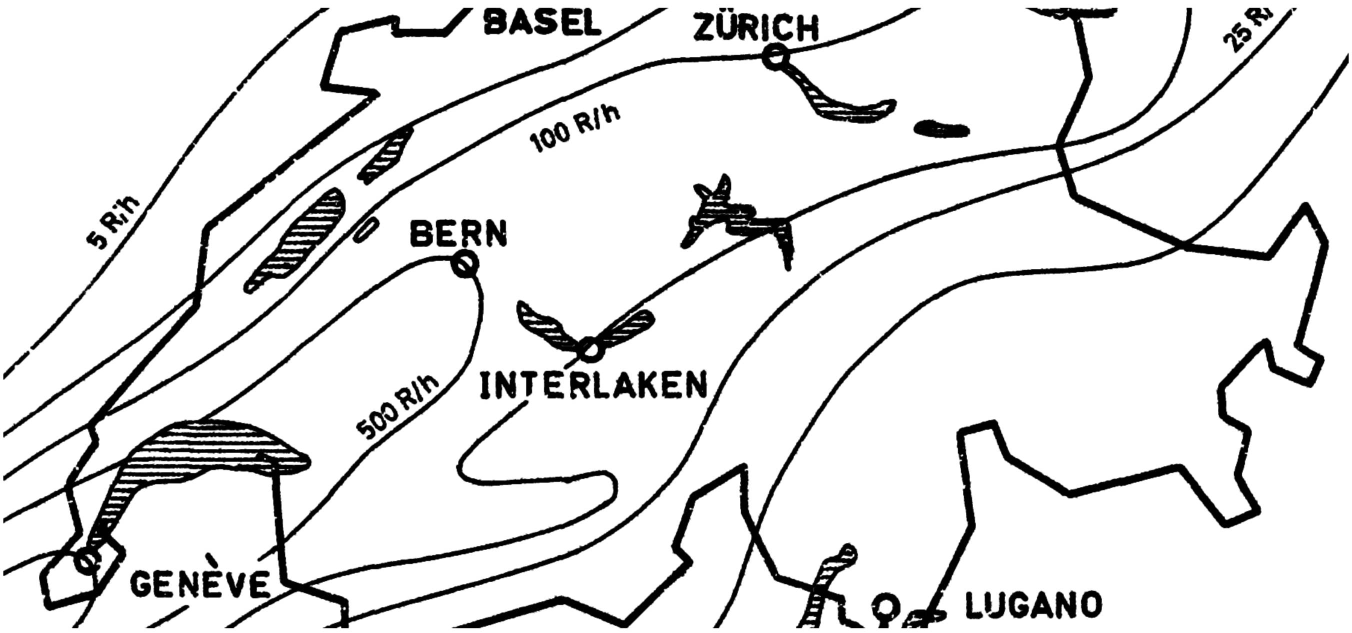
Fig. 4.3—Decay of residual gamma activity after Mike shot.

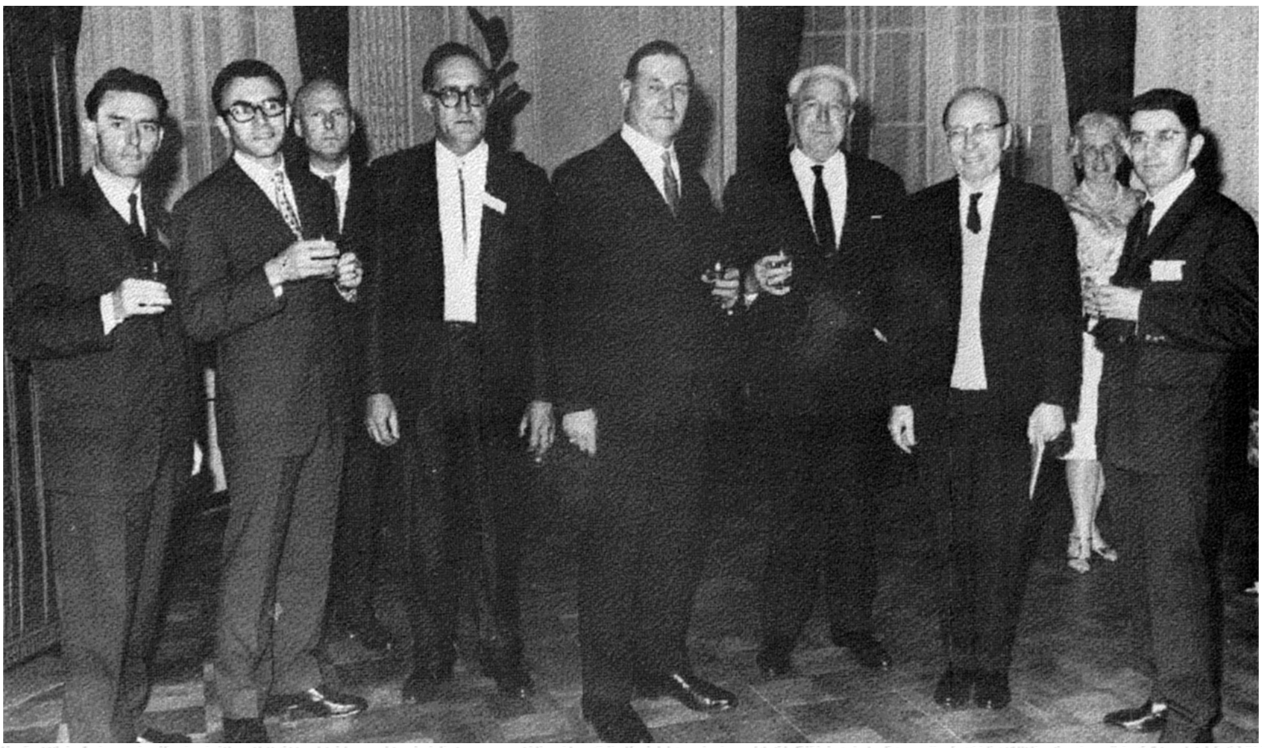
FACHVERBAND FÜR STRAHLENSCHUTZ E.V.

Mitgliedsgesellschaft der International Radiation Protection Association (IRPA)

PROCEEDINGS of a SYMPOSIUM

RADIOLOGICAL PROTECTION OF THE PUBLIC IN A NUCLEAR MASS DISASTER

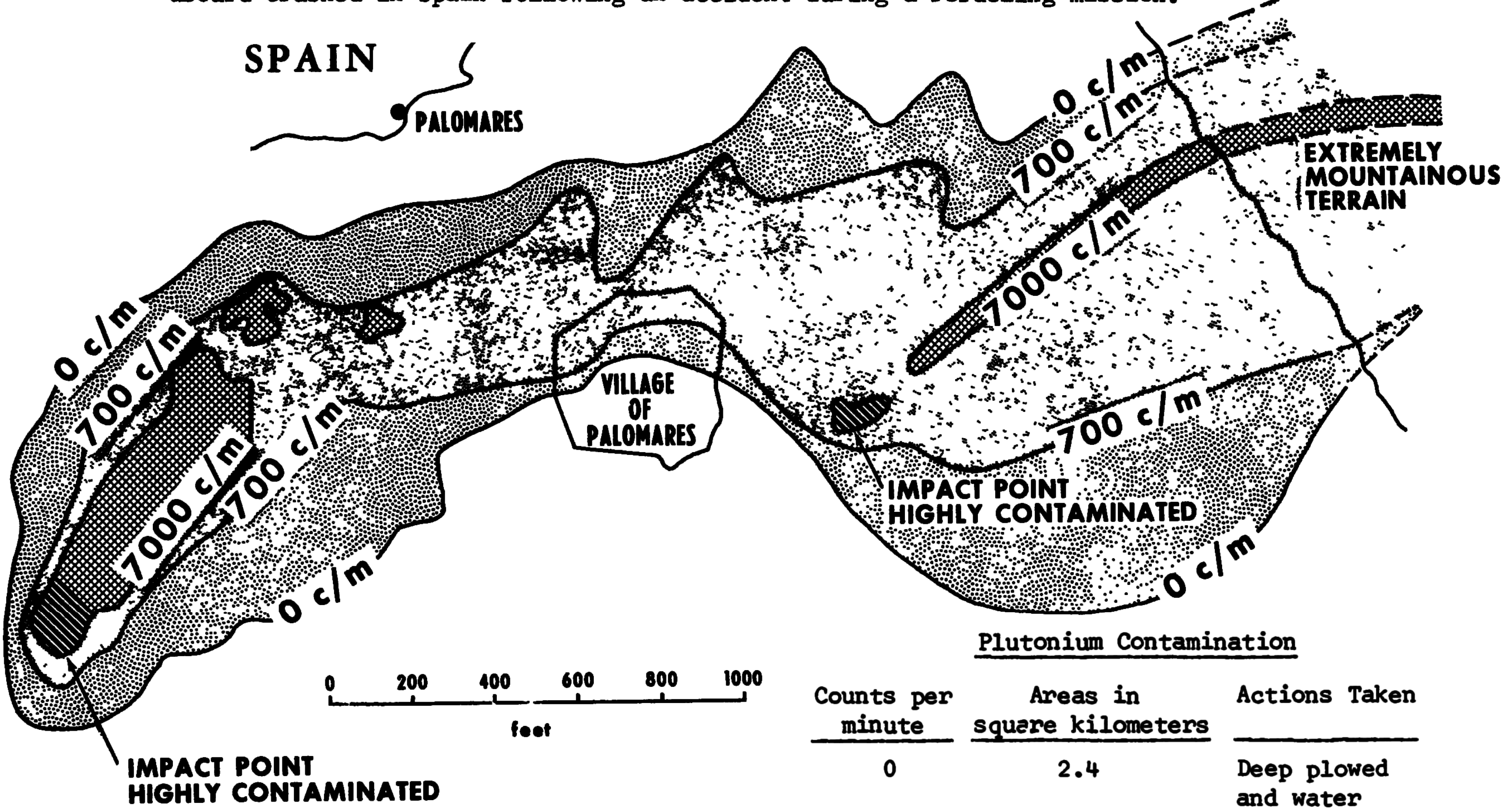




Front row: O. Burkhardt, Administrative Secr. of the Symposium - S. Prêtre, Pres. of "Fachverband für Strahlenschutz" - Dr. C.F. Miller, URS Corp., Burlingame, California - Bundesrat L. von Moos, Member of the Swiss Government, Minister of Justice and Police - W. König, Dir. of the Swiss Federal Office of Civil Defense - Prof. E.P. Wigner, Princeton Univ., Nobel Prize in Physics 1963 - H. Brunner, Scientific Secr. of the Symposium.

INTERLAKEN, SWITZERLAND, 26 MAY–1 JUNE 1968

On January 17, 1966, a B-52 U.S. Air Force aircraft with nuclear bombs aboard crashed in Spain following an accident during a refueling mission.



Plutonium Contamination

Counts per minute	Areas in square kilometers	Actions Taken
0	2.4	Deep plowed and water
700	2.0	(Deep plowed,
7,000	0.17	(watered and (vegetation removed
over 60,000	0.022	Surface scraped

Plutonium quickly oxidizes forming insoluble plutonium oxide.

The potential sources of inhalation of plutonium under these conditions are one, the cloud of radioactive material as it rolls by immediately after the event and, two, resuspension of the plutonium from the ground into the air afterwards. Available data indicate that the first source will probably result in a higher amount of plutonium being deposited in the lungs.[1.]

In short, experiments[1., 2.] showed that if a person were exposed to the highest concentration of plutonium in the cloud from such an accident he might receive a total radiation dose to the lungs of about 5 to 10 rem. The second of the major field tests was conducted under inversion meteorological conditions in order to maximize the concentration in the air at ground level.

1. Summary Report, Test Group 57; Report No. ITR-515 (Del.), Shreve, J.D., Jr. April 1958.
2. Operation Roller Coaster 1963. "Biological Studies Associated with a Release of Plutonium." Wilson, Robert and Terry, Jack.

THE NATURE AND BEHAVIOR OF LOCAL FALLOUT

By

Carl F. Miller

THE FORMATION PROCESS

The larger glassy particles, formed from vaporized and melted soil material, are entrained in the fireball before it cools to the melting point of the soil. During this time, the larger melted particles not only collide and coalesce with the smaller liquid soil droplets, but serve as a condensation media for other vaporized condensable fission products. The crystalline particles, entering the fireball after it has cooled to temperatures less than the melting point of the soil material, collect only late-condensing fission product radionuclides on their surfaces in addition to intercepting a few of the small vapor-condensed particles. The late-condensing fission products consist mainly of the volatile elements such as Sb, Te, and I, and the daughter products of rare gases such as Rb and Cs.

The derived specific activity of the local fallout from Shot SMALL BOY, a low-yield device detonated near ground surface at the Nevada Test Site, is shown as a function of particle diameter in Figure 1. The low values of the specific activity for the smaller particles resulted from the unavoidable presence of extraneous local dust particles in the collected samples.

The curve of Figure 1 may be represented by:

$$C = \frac{3.5 \times 10^{18}\left[1 - e^{-6.9 \times 10^{-4} d}\right]}{d}, \quad d = 50 \text{ to } 4{,}000 \text{ microns} \qquad (1)$$

where d is the particle diameter in microns and C is in fissions per gram. The range in d indicates that essentially all of the radioactive particles falling in the local fallout area were greater than 50 microns and that essentially none were found larger than 4,000 microns. The form of Equation 1 and the numerical coefficient values indicate that the gross radionuclide content of the particles is essentially proportional to particle volume or weight for particles with diameters between about 50 and 200 microns. For particles with larger diameters, the radionuclide content becomes increasingly concentrated on the surface of the particles and at diameters of about 2000 microns and larger, the radionuclide content is essentially proportional to

surface area (i.e., to 1/d). The specific activity of the smaller particles would be expected to be larger than the limiting value of Equation 1 and should increase somewhat as the diameter decreases below about 50 microns.

The major significance of the two-stage fallout formation process, aside from the resulting bimodal particle type composition, is that the radionuclides that condense into the liquid droplets in the first stage become immobilized with regard to latter contamination of water and cycling in food chains; but the radionuclides that condense in the second stage on the surfaces of the particles may not be permanently immobilized and do become involved in later biochemical processes.

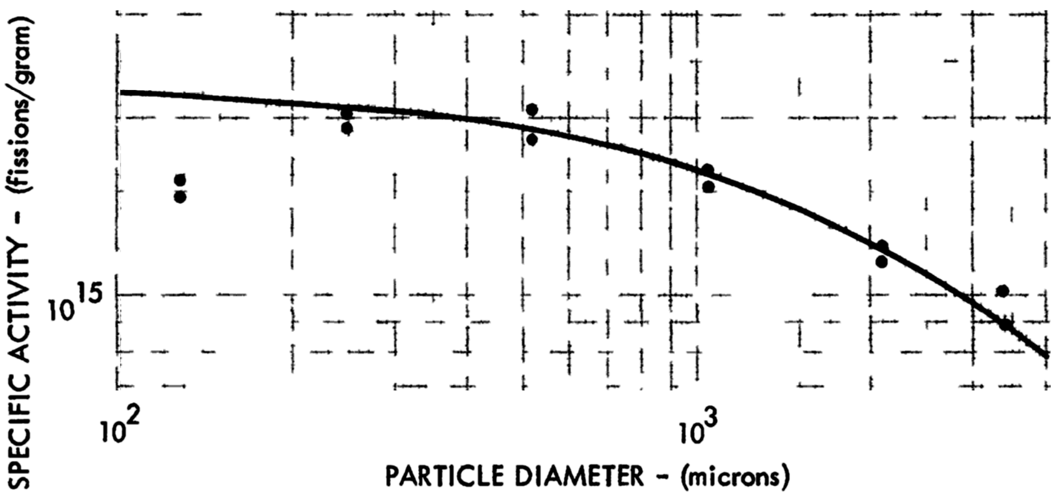


Figure 1. Specific Activity For Shot Small Boy.

Figure 2. Example Representations of Observed Fallout Patterns.

As the fireball cools and rises into the atmosphere, toroidal circulations take place. This circulation apparently concentrates the remaining gaseous radionuclides and smaller particles in the center of the toroid and, due to the downward flow of air at the periphery, accelerates the falling out of the larger particles. Thus, the time of arrival of the largest fallout particles is usually less than is estimated on the basis of free fall from the bottom of the cloud.

BETA RADIATION HAZARDS AND BETA-GAMMA RELATIONSHIPS ASSOCIATED WITH LOCAL FALLOUT

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Four cases of beta-ray burns of the hands, which occurred during an atomic bomb test at Eniwetok, have been reported by Knowlton et.al.[2] Two of the men received beta ray doses of 5,000 - 10,000 rads, another received 8,000 - 16,000 rads, and the fourth received 3,000 - 4,500 rads. For all but the smallest dose, skin damage was so extensive that grafts were required. There was loss of mobility of some of the fingers. In one case serious ulcers persisted for periods greater than 100 days after the exposure. The effects of the smallest dose were less pronounced; however, the damage persisted for a period greater than 50 days.

Amount of Transepidermal Radiation Required for the Production of Recognizable Transepidermal Injury (Porcine Skin) From Ref. (1)

Isotope	Maximum Beta Energy (Mev)	Surface Dose Required (rep)	Estimated Dose at 0.09-mm Depth (rep)
S-35	0.17	20,000	1200
Y-91	1.53	1,500	1200

2000-4000 rad	Early erythema under 24 hours Skin breakdown in 2 weeks
4000-10,000 rad	Severe erythema in 24 hours Severe skin breakdown in 1-2 weeks
10,000-30,000 rad	Severe erythema in 4 hours Severe skin breakdown in 1-2 weeks
30,000-100,000 rad	Immediate skin blistering (less than 1 day)

The expected beta dose rate at contact in a large field contaminated by fallout was calculated[10] to be 40 times the gamma exposure-rate reading taken at 3 feet. For example if the gamma reading at 3 feet is 100 R/hr, the expected beta dose rate at contact will be 4,000 rads/hr. This is true for a beta-particle to gamma-photon ratio of 1. This ratio is approximately equal to unity for times after a nuclear burst of a few hours to 3 or 4 months. At early times (a few minutes to an hour) the ratio may be as high as 2, in which case the beta dose rate will be 80 times the gamma exposure rate.

The beta doses associated with local fallout contamination of terrain and clothing have also been estimated by Pretre[11] who compared the beta and gamma doses to people exposed to terrain and clothing contaminated with fallout. His calculations were essentially in agreement with those reported in reference 10.

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11. Pretre, S., "Importance Biologique Relative des Doses Beta de la Peau Comparees aux Doses Gamma du Corps Entier", Section ABC 33/22 Bulletin ABC No. 7, April 1965.

http://www.osti.go OSTI Identifier: 4822127 Report CONF-680507 (31 October 1969): Radiological Protection of the Public in a Nuclear Mass Disaster, Symposium, Interlaken, Switzerland, 26 May-1 June 1968

BASIC CHARACTERISTICS OF NUCLEAR RADIATION FROM FALLOUT

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Radioactivity may also be produced by neutron interactions within the weapon itself. In many weapons the primary radiation of this type is ^{239}Np (half-life, 2.3 days) produced by the reaction $^{238}U(n,\gamma)$ $^{239}U(\beta)$ ^{239}Np because of the presence of ^{238}U (see pp. 1690-91 of reference 17). The nuclide ^{239}U decays with a half-life of only 23.5 minutes so usually is not observed in significant amounts in fallout measurements.

Other materials besides uranium can be introduced into the regions surrounding the active portions of a nuclear weapon. These materials are then subjected to a tremendous neutron flux density when the weapon is detonated, with the result that many radioactive nuclei are formed. At one time the hazards produced by gamma radiations of a so-called cobalt bomb were discussed extensively. Based on what he considered reasonable assumptions, Dunning[18] calculated the residual-radiation exposure and exposure rate that one could expect from a one megaton nuclear weapon, containing cobalt, that derived half of its energy from fission and half from fusion. His conclusions are that the effect of the cobalt is almost insignificant at very early times but it becomes appreciable after several days. For example, his calculations indicate that one hour after detonation the gamma-ray exposure rate produced by the fission products is about 5.9×10^5 times the exposure rate produced by the ^{60}Co gamma rays, but after 30 days the fission-product exposure rate is only 0.02 times the ^{60}Co exposure rate. An infinite time extrapolation shows the contribution to the total-exposure by fission-product radiations and by ^{60}Co radiations to be approximately equal.

Comparison of Fallout and Fission Product Gamma-Ray Spectra

Cook[19] has compared calculations by Nelms and Cooper[15] of expected gamma-radiation spectra from radioactive fission-product nuclides with measured gamma-ray spectra of fallout samples. These comparisons indicate that there is a reasonably close resemblance between calculation and experiment for photons with energies greater than 290 keV. However, the ^{239}Np radiations in the experimental measurements usually completely obliterate the fission-product radiations in the energy regions between 100 and 290 keV.

(Np-239 and U-237 (in thermonuclear bombs) emit easily shielded soft ~ 0.1 MeV gamma rays.)

Experiments Using Real Fallout Fields

Mather et al.,[56] Huddleston et al.,[57] and Frank[58] have measured the gamma radiation emitted by fallout that resulted from two near-surface bursts at the Nevada Test Site. All three groups used scintillation spectrometers, with NaI(Tl) detectors, to measure pulse height distributions.

The effect of ground roughness has been determined in these experiments by measurements of the direct component of the radiation.

In both cases the effect of ground roughness could be simulated by assuming a plane source covered by a layer of earth. In the area where Mather et al. made their measurements, the layer of earth amounted to a thickness of 0.45 g/cm² plus 106 cm of air, and in the area measured by Frank a thickness of 0.95 g/cm² plus 122 cm of air.

Huddleston et al. compared their dose vs. angle of incidence measurements with a calculation by Spencer[44] to determine the effects of ground roughness. They found angular distributions from measurements made three feet above the surface which, when compared with calculations made by Spencer, are comparable to the radiation expected in air about 40 feet above a planar infinitesimally thin source. Further, they found the distribution over a dry-lake bed to closely approximate Spencer's calculated distribution for an air-equivalent distance of 20 feet, and over a plowed field an air-equivalent distance of between 40 and 60 feet.

The equivalent air thickness reported by Huddleston et al. is somewhat greater (if converted to g/cm²) than the equivalent earth thicknesses reported by Mather et al. and by Frank. The differences may have real significance or they may possibly depend on assumptions made in the calculations. The general conclusions derived from these results are that the use of an equivalent air attenuation to represent the soil attenuation produced by ground roughness effects appears to give results that are in reasonably good agreement with experimental observations.

17. Congress of the U. S., Special Subcommittee on Radiation, "The Nature of Radioactive Fallout and Its Effect on Man." U. S. Government Printing Office, Washington, D. C., 1957.

18. G. M. Dunning, Health Phys. 4, 52-54 (1960).

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44. L. V. Spencer. Structure Shielding Against Fallout Radiation from Nuclear Weapons. Nat. Bur. Std. Monograph 42 (1962).

USNRDL-TR-645

GROUND ROUGHNESS EFFECTS FOR FALLOUT-CONTAMINATED TERRAIN: COMPARISON OF MEASUREMENTS AND CALCULATIONS

J. M. Ferguson
7 May 1963   29 p.   UNCLASSIFIED

The effect of ground roughness on the radiation field above fallout-contaminated ground is studied. At past weapons tests, the dose rate over fallout-contaminated ground has been measured as a function of height and angle. These measurements are compared with calculations of the same quantities for 1.12-hr fission products uniformly distributed on a smooth plane. None of the experiments is detailed enough to lead to firm conclusions about the ground roughness effect. However, the data indicate that the ground roughness effect can be simulated by assuming that the fallout is buried under a thin layer of material. For desert terrain this thickness of material is equivalent to about 25 ± 10 ft of air. At 3 ft above the ground this corresponds to a reduction in dose rate by a factor of 0.6 to 0.7, compared to what would be received over a smooth plane.

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FIRST SESSION

ON

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MAY 27, 28, 29, AND JUNE 3, 1957

PART 1

Printed for the use of the Joint Committee on Atomic Energy

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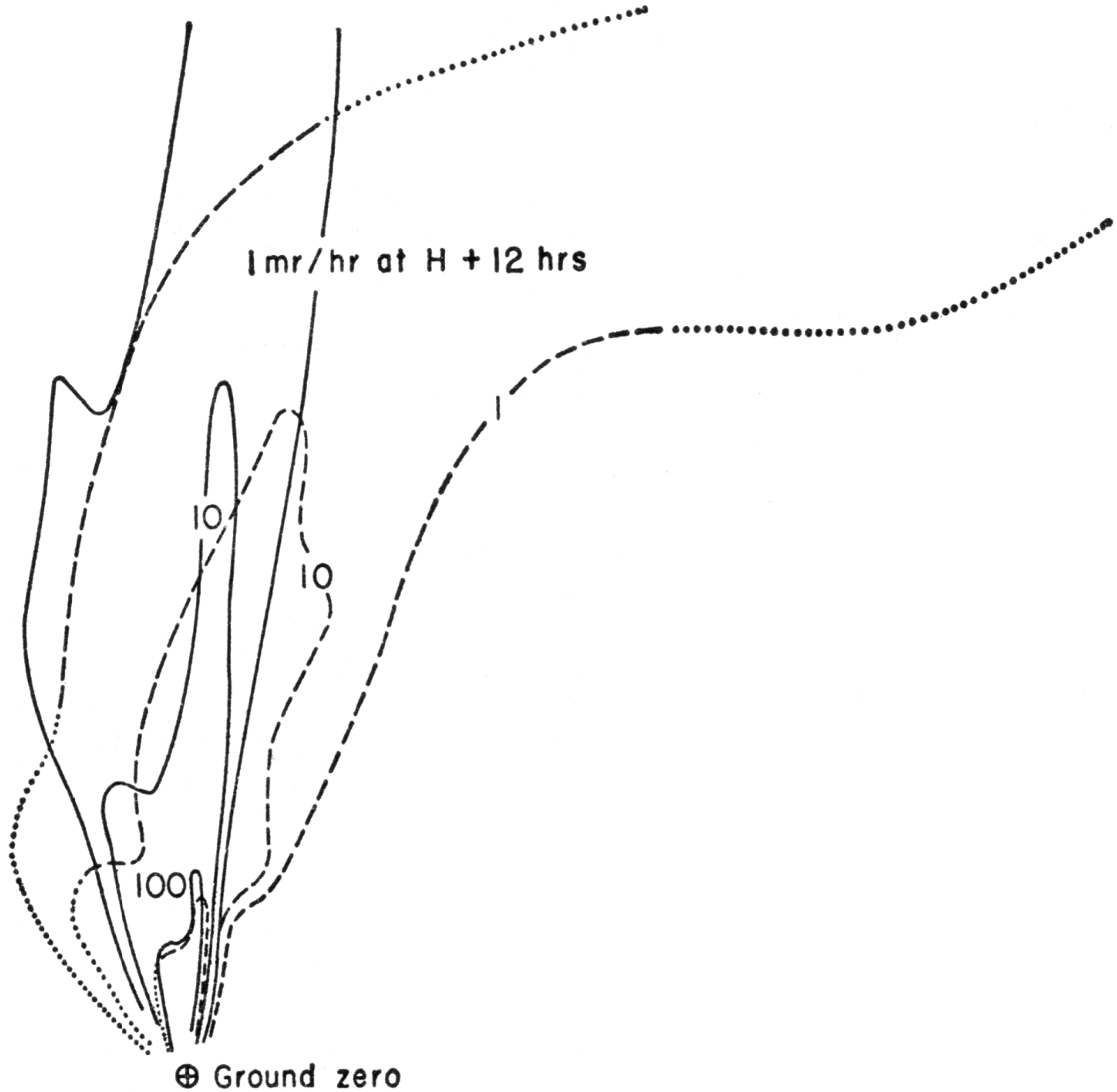

FIGURE 4.—The observed fallout distribution (dashed lines) and the pattern computed by the Weather Bureau using winds predicted at H–2 hours. May 5, 1955.

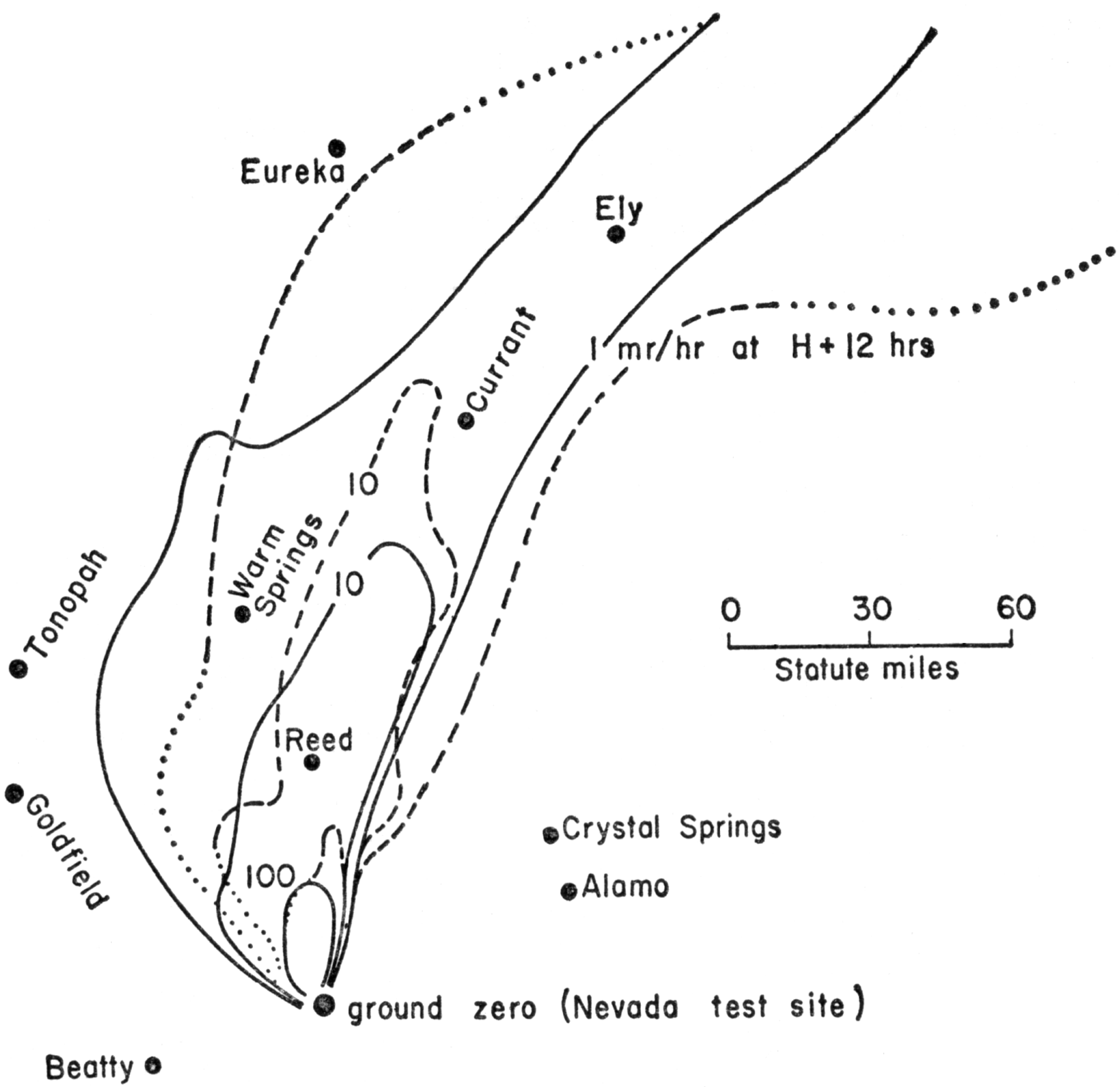

FIGURE 6.—The observed fallout distribution (dashed lines) and the pattern reconstructed by the Weather Bureau using a hand computation with time and space variation of winds (solid lines). May 5, 1955.

MYRON B. HAWKINS (b. 1920), USNR.DL.:

~~tion.~~[1 2 3 4] The contaminability of targets as related to micrometeorology and geometry have not been studied directly, but some information has been derived from experiments with other objectives.[5] As an example, a ship was exposed to fallout from a deep-water detonation.[6 7] The fallout arrived in a 15- to 20-knot wind on the starboard beam.

The following results were obtained:

(*a*) The contamination level (240 readings) on horizontal surfaces varied from 16 percent to 400 percent of the average, i. e., the largest was 25 times higher than the lowest.

(*b*) The gamma radiation level at 3 feet above the deck varied by a factor of 10.

(*c*) The average contamination level for vertical surfaces varied from the average horizontal reading as follows:

1. Forward part of the ship: 40 percent of horizontal average.
2. Aft part of the ship: 20 percent of horizontal average.
3. Lee side: 10 percent of horizontal average.
4. Windward side: approximately equal to horizontal average.

(*d*) Test panels at the stern of the ship had an average contamination level on vertical surfaces three times higher than levels on horizontal surfaces.[8]

Such data cannot be extrapolated or used for predictions without a better understanding of all of the factors involved.

In another example, small buildings and panels of typical building materials were exposed to fallout from land detonations.[4] The contamination levels on typical roofing materials was as much as 300 times higher than that on typical wall panels; or a vertical to horizontal relationship of about 0.3 percent. For panels of the same material, vertical readings were about 10 percent of the horizontal.

The two examples indicate considerable difference in the vertical to horizontal relationships. The characteristics of the fallout appear to have had a considerable influence on this distribution. For instance, the land detonation normally produces a "dry" fallout composed primarily of material from the crater. One can expect masses of 3 to 300 grams of material per square foot to be associated with significant radiation levels at early times. The fallout being a dry powder has little tendency to stick on vertical surfaces.

The fallout from deep-water detonations is largely composed of sea water salts. However, much of the water may evaporate, leaving particles that are damp, semicrystalline masses of a sticky nature. They are capable of sticking to vertical surfaces.

As indicated very little is known of the overall problem of contaminability. It is obvious, however, that two assumptions often made, i. e., ((1) that the fallout is distributed homogeneously on a uniform infinite plane, and (2) that vertical surfaces are not appreciably contaminated) are subject to serious limitations. The ability of a tactical force and/or a civilian population to exploit the variability of the fallout pattern depends upon knowledge we do not have on contaminability.

The contaminability of personnel exposed to the fallout event or working and living in contaminated environments is largely unknown. A study[9] indicating the significance of beta contact hazard to personnel and a requirement for the mass decontamination of personnel, emphasizes the need for additional contaminability information.

---

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[4] Strope, W. E., Protection and Decontamination of Land Targets and Vehicles, Operation Jangle, project 6.2, AFSWP–WT–400.

[5] Lee, H., M. B. Hawkins, Some Considerations of the Geometrical Distribution of Fallout Radiation Sources Over Targets, Proceedings of the Shelding Symposium held at USNRDL October 17–18, 1956, vol. II (USNRDL report in preparation), secret.

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Cost of Reclamation

Considerable data has been collected regarding the effectiveness of reclamation of targets contaminated by local fallout. The feasibility of applying these methods depends upon the following parameters:

(a) The time required to perform the reclamation must be short enough to make an appreciable saving in radiological exposure to mission personnel,

(b) The radiation exposure to reclamation personnel must be justified by the saving in exposure of mission personnel,

(c) The effort (manpower) and logistics required to reclaim the target must be compatible with the total effort available.

Thus, the cost of reclamation as measured in operating time, effort, radiation exposure, equipment, and supplies is an important determination.

It is impossible to generalize on these quantities for they are influenced by many factors.

The type of fallout, whether it be from a deep water, harbor or land detonation, influences the rate and/or method of decontamination. A deepwater-type fallout can be removed only to an extent of about 60 percent for a firehosing, scrubbing operation on ships,[1] the rate being about 40 square feet per minute. The same decontamination procedure at 6 times the rate of operation on a paved area contaminated by dry-land-type fallout will yield a removal of about 98 percent.[2] To achieve an equivalent removal on the ship, a surface removal technique would be required. Typical rates of operation are about 20 feet per minute for paint stripping[3] and about 7 feet per minute for removing a ⅛-inch thick layer of wood from the flight deck.[4]

The amount (or mass) of fallout on a surface influences the rate, particularly for harbor and dry-type fallout that must be transported over horizontal surfces for considerable distances. The following table shows an example of how the rate decreases with increasing masses of dry fallout for motorized flushing.[2]

Dry fallout gm/ft:[2]	*Motorized flushing rate, ft.²/min.*
10	670
33	650
100	580
330	300

The mass of fallout has no effect on the rate of operation for surface removal or earth moving techniques.

The rate of operation is influence by the surface characteristics of the target, rough surfaces, e. g., wood shingles, requiring longer time than smooth, e. g., metal surfaces. The following table is an example of the influence of surface roughness on rate of operation:[2]

Firehosing of dry contaminant

Material	Effectiveness (percent removed)	Rate (ft²/min/hose)
Corrugated metal	97	65
Composition shingles	95	50
Wood shingles	89	35

The rate of reclamation by earth moving is influenced by soil characteristics. Standard earth moving practice has developed considerable information on this subject.

[1] AFSWP, ITR 1323, preliminary report, Operation Redwing, project 2.9, Standard Recovery Procedure for Tactical Decontamination of Ships. Confidential.

[2] Field Evaluation of Cost and Effectiveness of Basic Decontamination Procedures for Land Target Components, Sartor, J. D., Curtis, H. B., etc., USNRDL–TR in preparation. Unclassified.

[3] Rates approaching 50 square feet per minute are possible if removal of only the surface layer of paint gives the required reduction in radiation intensity.

[4] Proof Testing of AW Ship Countermeasures, Operation Castle, project 6.4 WT-927, Molumphy, Bigger. Confidential.

The degree of mechanization obviously influences rate of operation. The following example compares firehosing rate with that of motor flushing for harbor-type fallout. Also shown are the influence of mechanization on effort and radiation exposure.[2 5]

Criteria for comparison	Actual performance or cost		
	Firehosing	Motorized flushing	Relative cost FH/MF
1. Operating rate per unit, hr/10^6 ft^2	222	30	7.4
2. Personnel required per unit	5½	2	2.75
3. Effort (direct labor), man-hr/10^6 ft^2	1,210	60	20.0
4. Radiation shielding factor	1.0	0.5	2.0
5. Relative cost in radiation dose	1,210	30	40.0

Target complexity obviously influences rate of operation. For optimum performance, spacings between target components must be large enough to permit mechanized equipment to be used.

A simplified example will help indicate the time, manpower, and basic supplies required for recovery of a target complex. The following criteria are assumed:

(*a*) Target: City of San Francisco.
(*b*) Fallout: Harbor-type at 33 gms/ft^2.
(*c*) Area to be recovered: About 25 square miles consisting of—
1. All paved areas.
2. All industrial and commercial areas and buildings.
3. 50 percent of the park areas.
4. 10 percent of the residential areas and buildings.

(*d*) Methods: Firehosing and earth moving.

The following table indicates an estimate[5] of the cost of reclaiming these critical areas:

Cost of decontaminating critical areas of San Francisco through use of available firefighting and earth moving equipment for removing slurry contaminant

	Firehosing			Earth moving, land areas	Grand total
	Roofs	Paved surfaces	Subtotal		
1. Time to complete decontamination (24-hour days)	16.8	11.7	28.5	13	----------
2. Direct labor (number of men)	----------	----------	4,000	2,800	6,800
3. Total labor, direct and support (number of men)	----------	----------	6,000	4,900	10,900
4. Total effort (8-hour man-days)	101×10^3	70×10^3	171×10^3	64×10^3	235×10^3
5. Labor cost at $10 per man-day	----------	----------	1.71×10^6	0.64×10^6	2.35×10^6
6. Water required for decontamination (gallons)	362×10^6	314×10^6	676×10^6	----------	----------
7. Fuel required (gallons):					
(*a*) Gasoline	145,000	101,000	246,000	95,000	341,000
(*b*) Diesel fuel	----------	----------	----------	195,000	195,000

As can be seen, the reclamation is feasible in what appears to be a reasonable time. The amount of equipment required is within the capability of existing sources in San Francisco. The manpower is not too excessive considering the numbers of people available. The water requirements are within the capability of the normal supply. Fuel consumption is less than normal daily requirements. The greatest problem would undoubtedly be that of organizing, training, supervising, and controlling 11,000 men.

Automatic decontamination devices such as the washdown system have, as an important advantage, the capability of reclamation at very early times with no expenditure of manpower or radiation exposure. They can be extremely effective (i. e., removal of 90–95 percent) even on sea-water-fallout.[4] However, they do require expenditure of funds before the war begins.

[5] Engineering Approach to Radiological Decontamination, Hawkins, M. B. (Paper to be given ASME semiannual meeting, San Francisco, June 1957.) Unclassified.

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JUNE 4, 5, 6, AND 7, 1957

PART 2

Printed for the use of the Joint Committee on Atomic Energy

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TABLE V.—*Decontamination of radioactively contaminated water by slurrying with clay*

Contaminant	pH	Clay concentration, p. p. m. — 1,000	Clay concentration, p. p. m. — 3,000
		Percent removal	
Ru^{106}–Rh^{106}	5.2	50.5	61.5
Zr^{95}–Nb^{95}	7.5	98.0	99.4
Sr^{90}–Y^{90}	7.7	83.4	92.9
I^{131}	7.5	4.9	3.4
$Ce^{141,144}$–Pr^{144}	8.0	99.7	99.9
Ba^{140}–La^{140}	7.8	88.8	94.3
MFP-1	8.8	82.0	86.3
MFP-2	9.0	70.0	72.8
MFP-3	7.7	79.0	83.6

TABLE VI.—*Removal of radioactive material by distillation (60 gallon/hr thermocompression unit)*

Run No.	Contaminant	Activity of feed, d/m/ml	Removal of activity expressed as decontamination factor	Percent
1	MFP-1	22,060	4.10×10^3	99.98
2	MFP-2	97,400	4.97×10^3	99.98
3	MFP-3	31,150	3.59×10^3	99.97
4	MFP-4	62,400	3.52×10^2	99.72
5	Pa^{233}	41,030	2.31×10^3	99.96
6	I^{131}	60,900	7.04×10^2	99.86
7*	MFP-5	38,910	1.09×10^3	99.91
8*	MFP-4	69,700	1.00×10^4	99.99
9*	MFP-1	12,020	1.70×10^4	99.99
10*	I^{131}	45,600	1.28×10^3	99.92
11*	Pa^{233}	25,300	5.80×10^3	99.98

*Glass wool reflux condenser used.

NOTES

MFP-1 was 3-year-old fission product mixture.
MFP-2 was a 2-week-old mixture from disolution of a reactor slug.
MFP-3 was composite sample or ORNL liquid waste.
MFP-4 concentrate from ORNL liquid waste evaporator.
MFP-5 mixture to simulate the material expected 10 days after atomic detonation.

ORNL-5037

NUCLEAR WAR SURVIVAL SKILLS

Cresson H. Kearny

Date Published—September 1979

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830

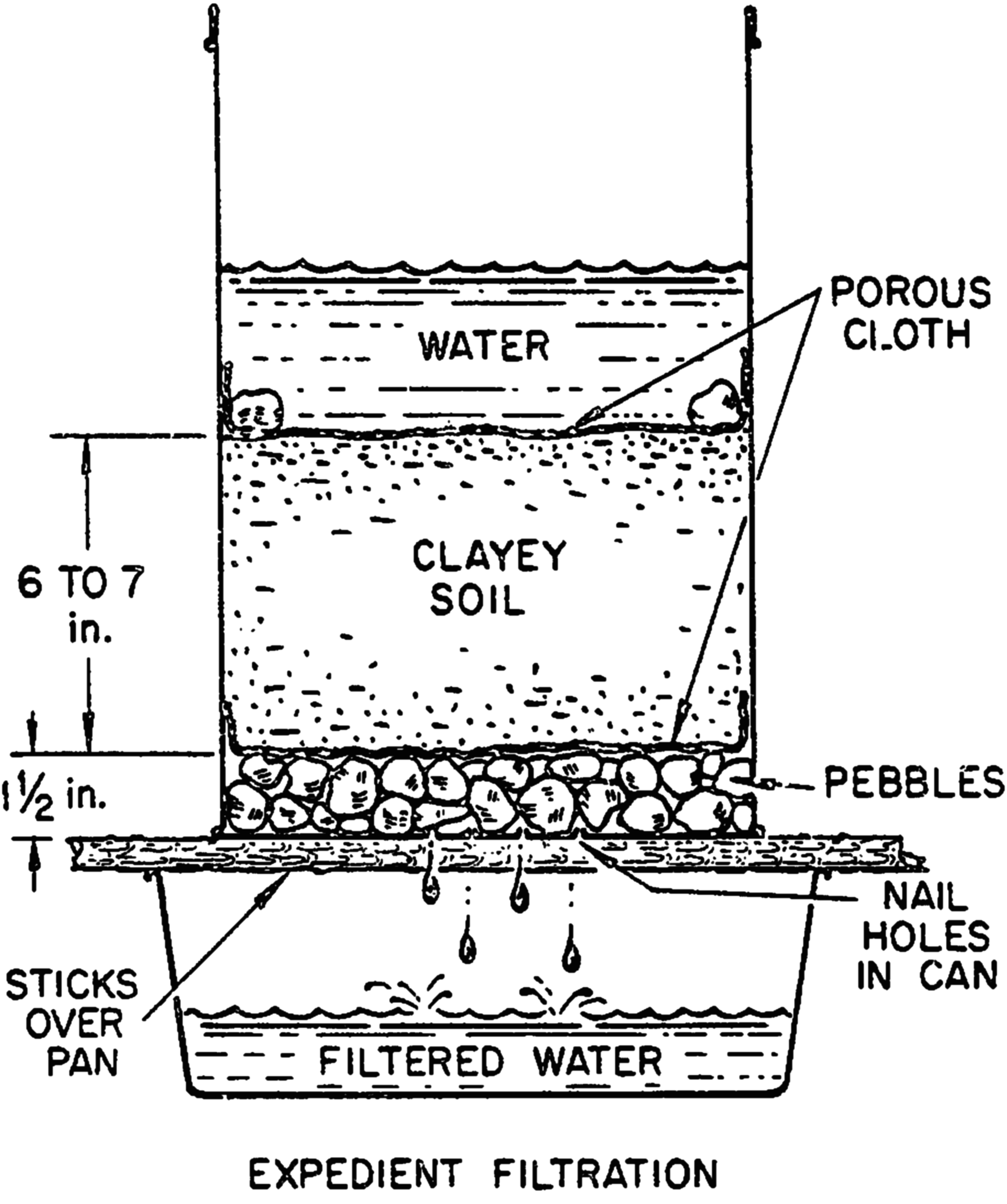
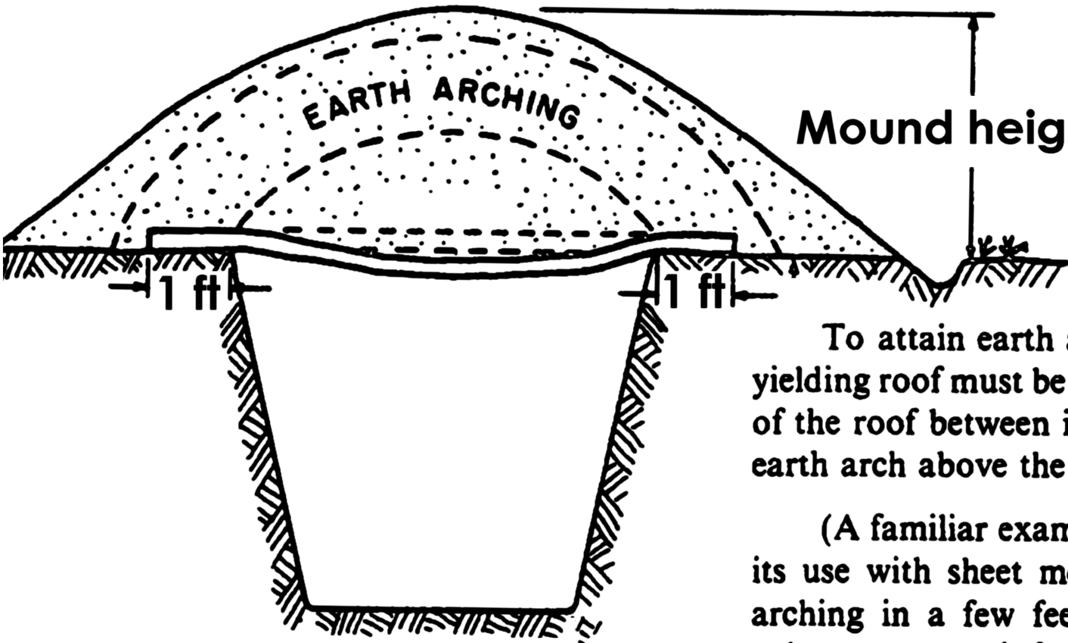


Fig. 8.11. Expedient filter to remove radioactivity from water.

EARTH ARCHING USED TO STRENGTHEN SHELTERS (Source: C. H. Kearny, ORNL-5037)



To attain earth arching, the earth covering the yielding roof must be at least as deep as half the width of the roof between its supports. Then the resultant earth arch above the roof carries most of the load.

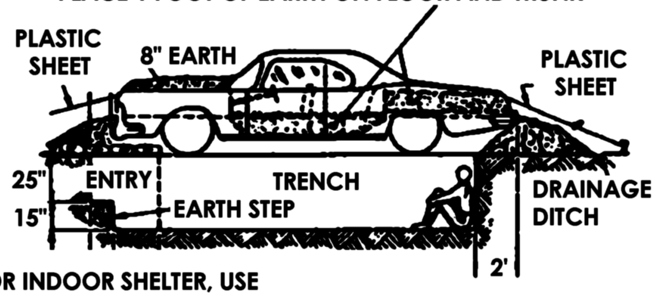
(A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.)

CAR-OVER-TRENCH FALLOUT SHELTER

DOORS OR LOGS CAN BE USED IN PLACE OF CAR.

BANK EXCAVATED EARTH 20 INCHES HIGH AROUND CAR
PLACE 8" OF EARTH ON CAR HOOD

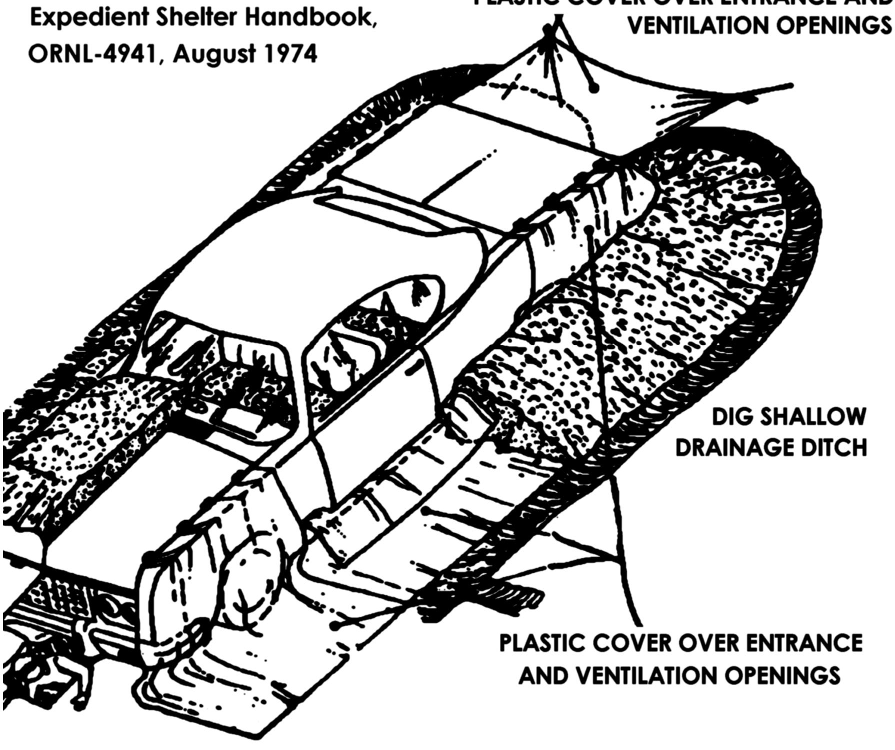
COVER FLOOR AND TRUNK WITH PLASTIC SHEET
PLACE 1 FOOT OF EARTH ON FLOOR AND TRUNK



FOR INDOOR SHELTER, USE BAGS OF WATER INSIDE BOXES AROUND & ON TABLE

(CAR-OVER-TRENCH FIRST APPEARED IN "LOW-COST FAMILY SHELTERS," OCT. 1961 STANFORD RESEARCH INSTITUTE.)

G. A. Cristy and C. H. Kearny, Expedient Shelter Handbook, ORNL-4941, August 1974



PLACE SAND-FILLED BAGS (SANDBAGS) AROUND ENTRANCE AND BANK EARTH AROUND THEM

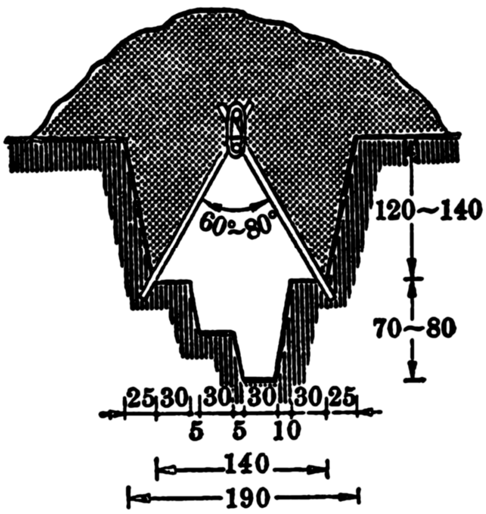


图 3-107 人字形骨架避弹所

CHINESE SHELTER SURVIVED 20 PSI PEAK OVERPRESSURE: THIN POLES WERE PROTECTED BY EARTH-ARCHING (DIMENSIONS IN CM.)
Source: C. H. Kearny, ORNL-5037

SKIN BURNS FROM HEATED DUST (THE POPCORNING EFFECT)

When exposed grains of sand and particles of earth are heated very rapidly by intense thermal radiation, they explode like popcorn and pop up into the air. While this dust is airborne, the continuing thermal radiation heats it to temperatures that may be as high as several thousand degrees Fahrenheit on a clear day in areas of severe blast. Then the shock wave and blast winds arrive and can carry the burning-hot air and dust into an open shelter. Animals inside open shelters have been singed and seriously burned in some of the nuclear air-burst tests in Nevada.

Thus Japanese working inside an open tunnel-shelter at Nagasaki within about 100 yards of ground zero were burned on the portion of their skin that was exposed to the entering blast wind, even though they were protected by one or two turns in the tunnel. (None of these Japanese workers who survived the blast-wave effects had fatal burns or suffered serious radiation injuries, which they certainly would have suffered had they been outside and subjected to the thermal pulse and the intense initial nuclear radiation from the fireball.)

Experiments conducted during several nuclear test explosions have established the amount of thermal radiation that must be delivered to exposed earth to produce the popcorning effect.

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

PUBLISHED
FOR THE HOME OFFICE AND THE AIR MINISTRY BY
HIS MAJESTY'S STATIONERY OFFICE
LONDON
1946

Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to "flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties. See paragraph 40.

Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage. See paragraph 41.

DASA 1271

BIOLOGICAL EFFECTS OF BLAST

by

Clayton S. White, M.D.

Presented before
The Armed Forces Medical Symposium
Field Command, Defense Atomic Support
Agency, Sandia Base, Albuquerque, New Mexico
November 28, 1961

Technical Progress Report
on
Contract No. DA-49-146-XZ-055

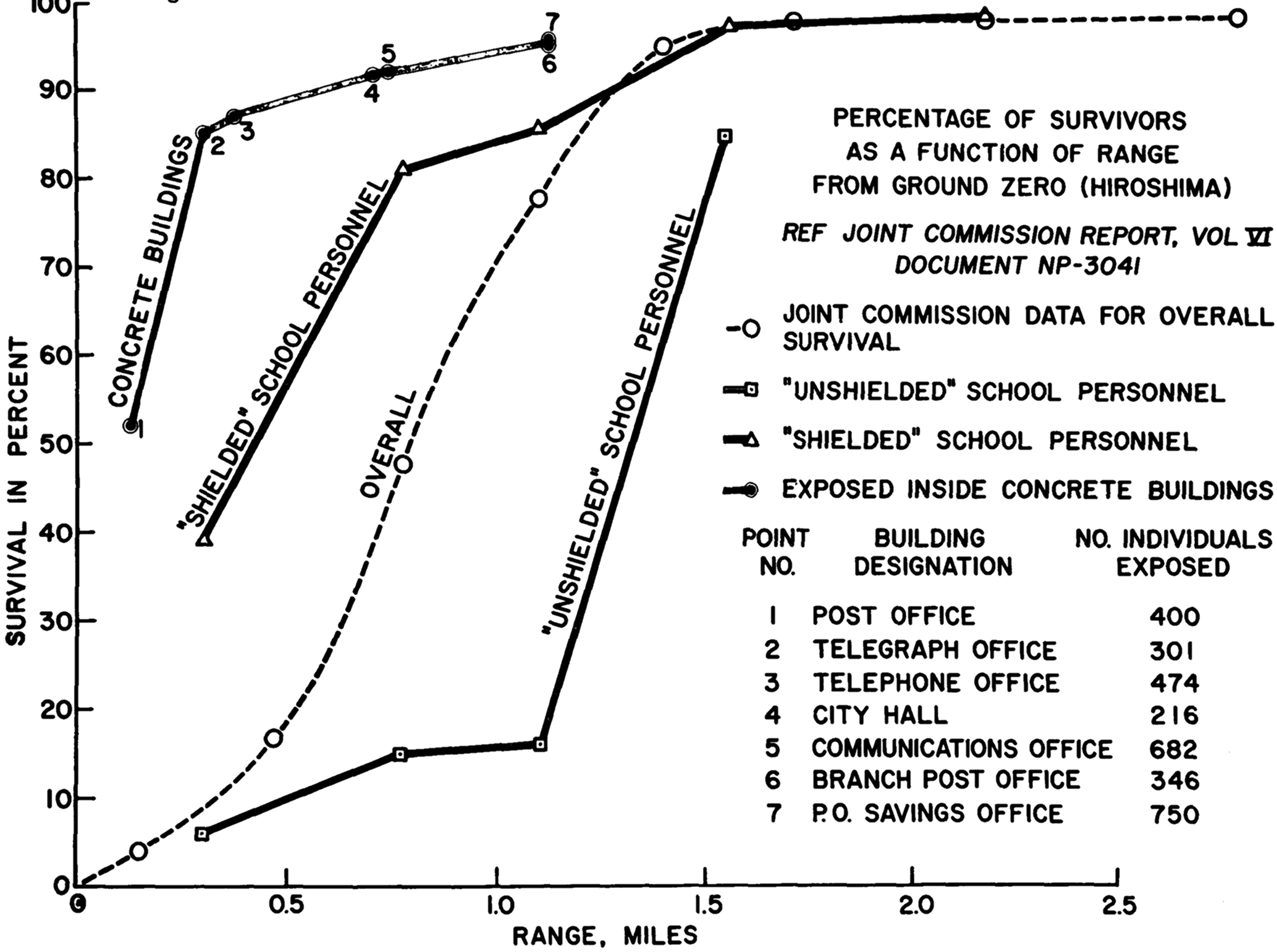
This work, an aspect of investigations dealing with the Biological Effects of Blast from Bombs, was supported by the Defense Atomic Support Agency of the Department of Defense.

Lovelace Foundation for Medical Education and Research

Albuquerque, New Mexico

December 1961

Fig. 44



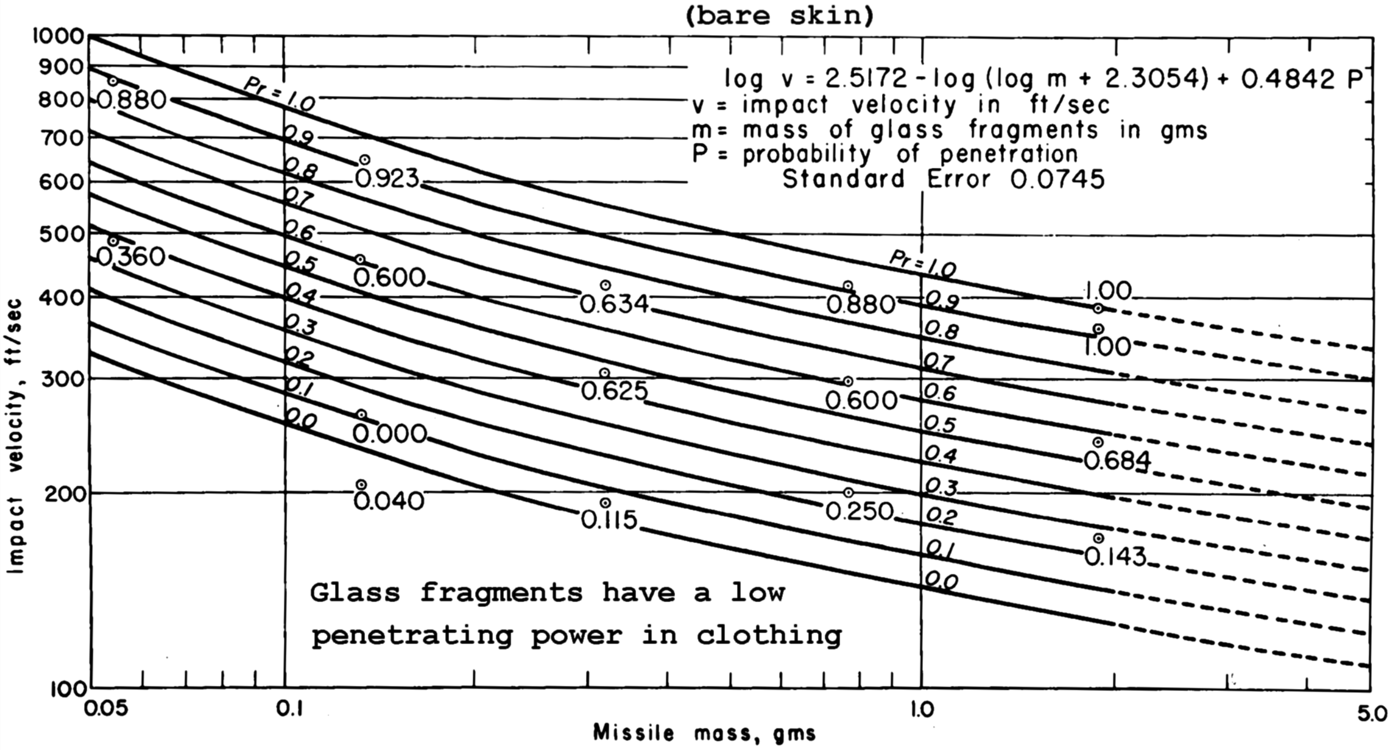
Oughterson, A. W., LeRoy, G. V., Liebow, A. A., Hammond, E. C., Barnett, H. L., Rosenbaum, J. D. and Schneider, B. A., "Medical Effects of Atomic Bombs — The Report of the Joint Commission for Investigation of the Effects of the Atomic Bomb in Japan," Vol. VI, AEC Technical Information Service, Oak Ridge, Tennessee, July 6, 1951.

TABLE 5 Hiroshima*

Items of Interest**	Conditions of Exposure: Concrete buildings	Inside schools	Mixed (average)	Outside schools
Range for 50% survival - mi	0.12	0.45	0.8	1.3
Estimated "free"-field effects at range for 50% survival				
Max side-on overpressure - psi	37	20	7.9	3.6
Max wind - mph	780	500	240	170
Thermal radiation - cal/cm^2	140	58	24	9
Initial ionizing radiation - rems	59,000	5800	480	15

*Scaled for a 20 kt burst at 1850 ft (0.35 mi) above a sea-level surface.
**The values shown in the body of the table will require adjustment later to be consistent with a refinement of yield estimations for the Hiroshima explosions.

Probability of penetration of glass fragments into the abdomen (bare skin) Fig. 41



There are a number of simple lessons portrayed by these survival curves which actually relate human experience with a nuclear detonation. Let us consider some of the more important.

1. First, the 50 per cent survival ranges for the four curves from your right to left of 1.3, 0.8, 0.45 and 0.12 miles forcefully emphasizes the importance of the conditions of exposure.

2. The area of complete destruction at Hiroshima has been described as covering a circle of about 1.2-mile radius (4 square miles), a range at which 4-5 psi existed. At this range there was an over-all survival of near 90 per cent. It is apparent, therefore, that one must not confuse the area of complete destruction of houses (a physical concept) with "complete destruction" of people. Even in to near 0.2 mile, there was 5 per cent over-all survival. By way of emphasis, let it be clear that there was a marked difference between the ranges for physical and biological destruction at Hiroshima. The gloomy habit of confusing the two concepts is, I am afraid, as prevalent as it is unrealistic and, indeed, untrue.

3. The great good fortune of just being indoors and shielded against the most far-reaching effect, direct thermal radiation, is illustrated by the survival range of 0.45 mile for school personnel mostly inside compared with 1.3 miles for those mostly outside. This proved so even though the fact of being inside involved exposure to falling and flying debris, greater displacement potential and higher pressure reflections. Apparently, the latter hazards are relatively less than the dangers from direct thermal radiation.

4. The marked value of simply being inside concrete buildings is illustrated by the 50 per cent survival range of 0.12 mile.

MASS BURNS

Proceedings of a Workshop

13 - 14 March 1968

Committee on Fire Research, National Research Council, **Workshop on Mass Burns**, Proceedings of a Workshop on 13-14 March 1968, National Academy of Sciences, Washington, D.C., 1969 (AD 689 495).

Sponsored

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PREDICTION OF URBAN CASUALTIES AND THE MEDICAL LOAD FROM A HIGH-YIELD NUCLEAR BURST

L. Wayne Davis

Paper
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(Work Unit No. 2411H)

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through

Technical Management Office
U. S. Naval Radiological Defense Laboratory

0.67 kt is the TNT equivalent of 0.88 kt of ammonium nitrate.
(Note: at Texas City the S.S. Grandchamp contained 2.3 kt of ammonium nitrate in 100-lb paper bags, but only the 880 tons in No. 4 hatch caught fire and blew up in the initial explosion. The remainder just caused burning debris which set off a fire and later explosion of ammonium nitrate in the Highflyer.)

Delivered at

Workshop on Mass Burns
National Academy of Sciences
Washington, D. C.
March 13-14, 1968

The Dikewood Corporation
1009 Bradbury Drive, S. E.
University Research Park
Albuquerque, New Mexico 87106

PREDICTION OF URBAN CASUALTIES AND THE MEDICAL LOAD FROM A HIGH-YIELD NUCLEAR BURST

I. INTRODUCTION AND SUMMARY

This work is the result of Dikewood's second iteration at predicting urban casualties due to high-yield nuclear bursts as based on the Japanese nuclear-casualty data from Hiroshima and Nagasaki and on the casualties experienced from the detonation of the ammonium-nitrate fertilizer on board a ship docked at Texas City in 1947. (The first iteration was published in DC-FR-1028, Ref. 1, and DC-FR-1041, Ref. 2.) The Japanese data base has now been more than doubled, and much more information is available on the breakdown of casualties segregated by shielding category. (See DC-FR-1054, Ref. 3.)

Urban casualty predictions are made for nuclear detonations in the yield range from 1 to 50 Mt for scaled burst heights of 0, 300, 585, and 806 feet. (See DC-FR-1060, Ref. 4, to be published.) All casualty curves are given in terms of a reference 12.5-kt surface burst; they must be scaled to the megaton-yield range by the use of scaling curves which are also provided. It is not presently a field manual for easy casualty predictions. Although calculations may be performed by hand, a computer solution is recommended to facilitate the computations for any but the simplest problems. Plans are underway to develop the computer program.

II. CASUALTY CURVES FOR PERSONS IN OR SHIELDED BY STRUCTURES

A. DEVELOPMENT OF "BLAST" MORTALITY CURVES FROM JAPANESE AND TEXAS CITY DATA

A great deal of new information has been gathered concerning the biological effects of the nuclear attacks on Hiroshima and Nagasaki, Japan, during World War II. The data from over 35, 000 case histories were collected on magnetic tape, and the results of the analysis were published in DC-FR-1054 (Ref. 3).

The Japanese mortality curves for people in or shielded by structures are plotted as a function of overpressure in Figs. 1 and 2 for Hiroshima and Nagasaki, respectively. These curves are based on a yield for Hiroshima of 12.5 kt burst at a height of 1870 feet (scaled height of 806 feet) and a yield for Nagasaki of 22 kt burst at a height of 1640 feet (scaled height of 585 feet).

The mortality curves from the Texas City disaster of 1947, separated by shielding category, are given as a function of overpressure in Fig. 3. This surface burst* has been estimated to be equivalent to a nuclear yield of 0.67 kt.

The next step was to develop a set of "blast" mortality curves for a reference 12.5-kt surface burst. Of course, the ultimate goal was

---

*Ammonium-nitrate fertilizer exploded within the hold of a ship which was tied up at a pier.

to separate all of the biological damage according to the particular weapons effect which caused it (such as blast, prompt-thermal radiation, or initial-nuclear radiation). Then, each effect could be scaled separately to the higher yield of interest, and the results could be recombined. Joint effects cannot be scaled directly.

For people in or shielded by structures in Japan, the blast and initial-nuclear radiation were the dominant immediate effects. However, when one scales the results to the megaton range, the lethal effects of the initial-nuclear radiation drop out because the blast effects scale to greater ranges. Thus, the blast mortality curves are the set of greatest interest for persons in or shielded by structures. (Similarly, thermal mortality curves are the ones of greatest interest for the outside-unshielded persons.)

By examining a set of theoretical initial-nuclear-radiation mortality curves developed for Hiroshima and Nagasaki and comparing them with the total mortality curves, it could readily be seen that the initial-nuclear radiation played a large role in the deaths of thermally-shielded people located fairly close-in (at the high mortality levels) in the light structures. It is also an important effect even in the concrete structures.

By further comparing the mortality curves for Hiroshima and Nagasaki plotted as a function of overpressure (Figs. 1 and 2), it can

readily be seen that the initial-nuclear radiation was more important or dominant in Hiroshima than in Nagasaki. (It requires more overpressure in Nagasaki to produce the same percent mortality for the equivalent shielding category.) Thus, one would expect the pure blast mortality curves (with no initial-nuclear radiation present) to lie to the right (higher overpressures) of the equivalent Nagasaki curves.

As another boundary condition, the Texas City mortality curves, given in Fig. 3, show the results of blast alone for a lower yield of 0.67 kt. Since a set of blast-mortality reference curves for a 12.5-kt surface burst is the immediate goal, they would appear to lie to the left (lower overpressures) of the equivalent Texas City curves. Of course, this shift is due to the effect of the longer positive-phase duration at the higher yield; it requires less overpressure to produce the same damage at the higher yield. Thus, by scaling the pertinent shielding categories in Texas City up to 12.5 kt and by using the Nagasaki curves as the lower pressure boundaries, the pure blast mortality curves* for the reference 12.5-kt surface burst were developed and are shown in Fig. 4. These blast mortality curves for the reference surface burst are drawn as a smooth function of overpressure since this weapons effects parameter is considered to be the controlling factor in determining the mortality level.

---

*It is felt that any deaths in the Japanese data due to the secondary effects of fire have been eliminated by this process.

FIG. 1

TOTAL MORTALITY CURVES FOR HIROSHIMA

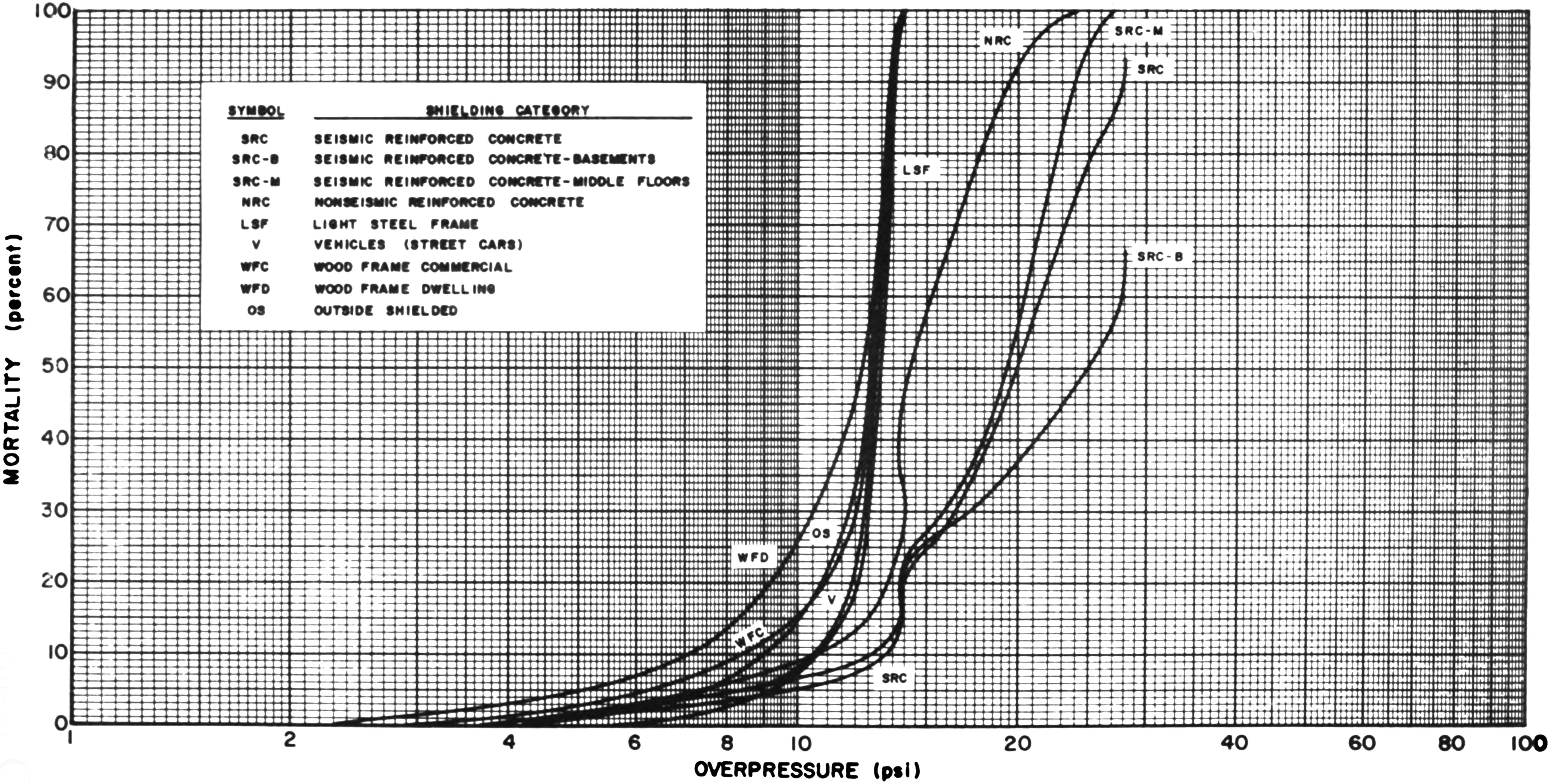


FIG. 2

TOTAL MORTALITY CURVES FOR NAGASAKI

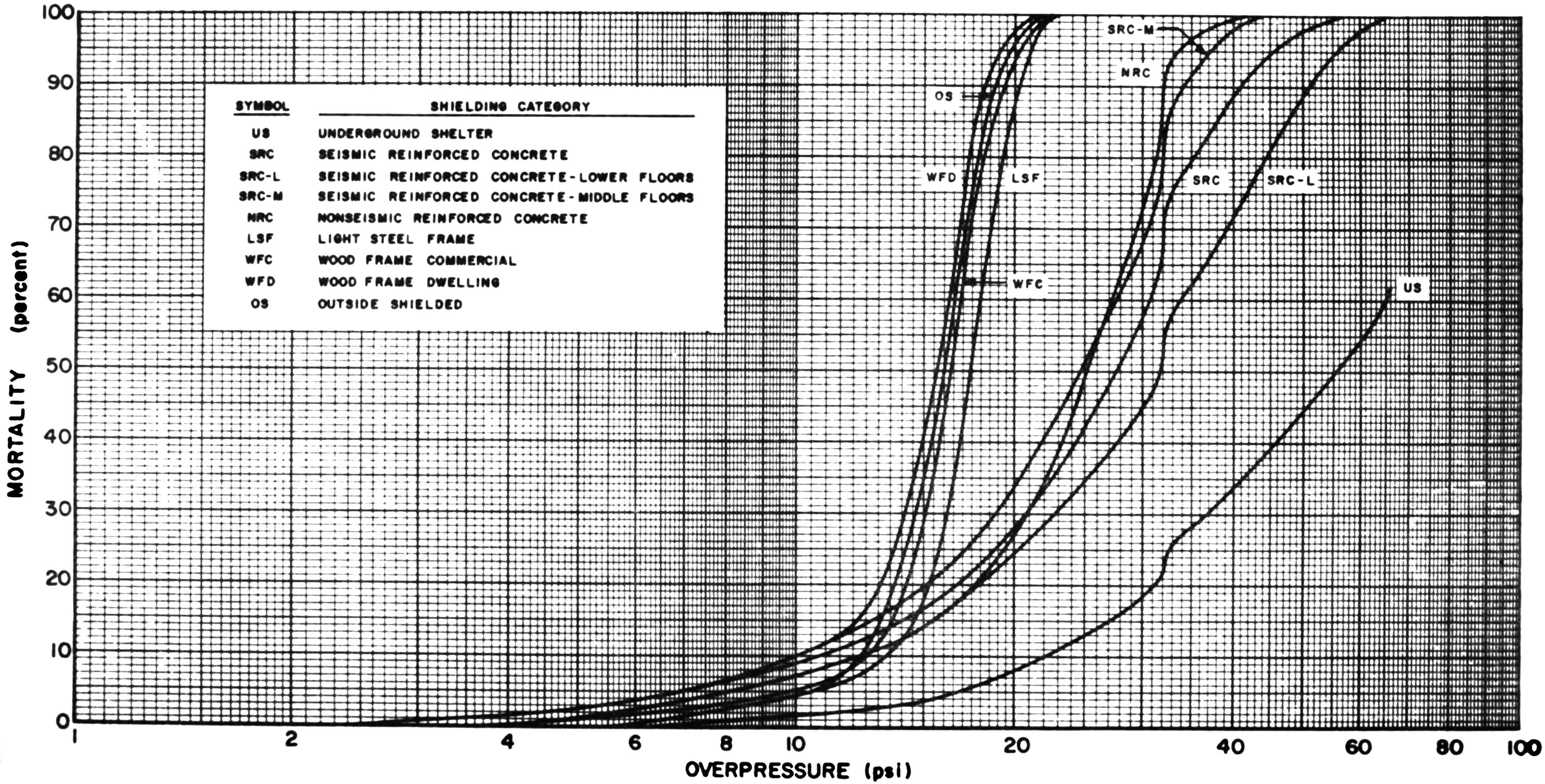


FIG. 3

TOTAL MORTALITY CURVES FOR TEXAS CITY

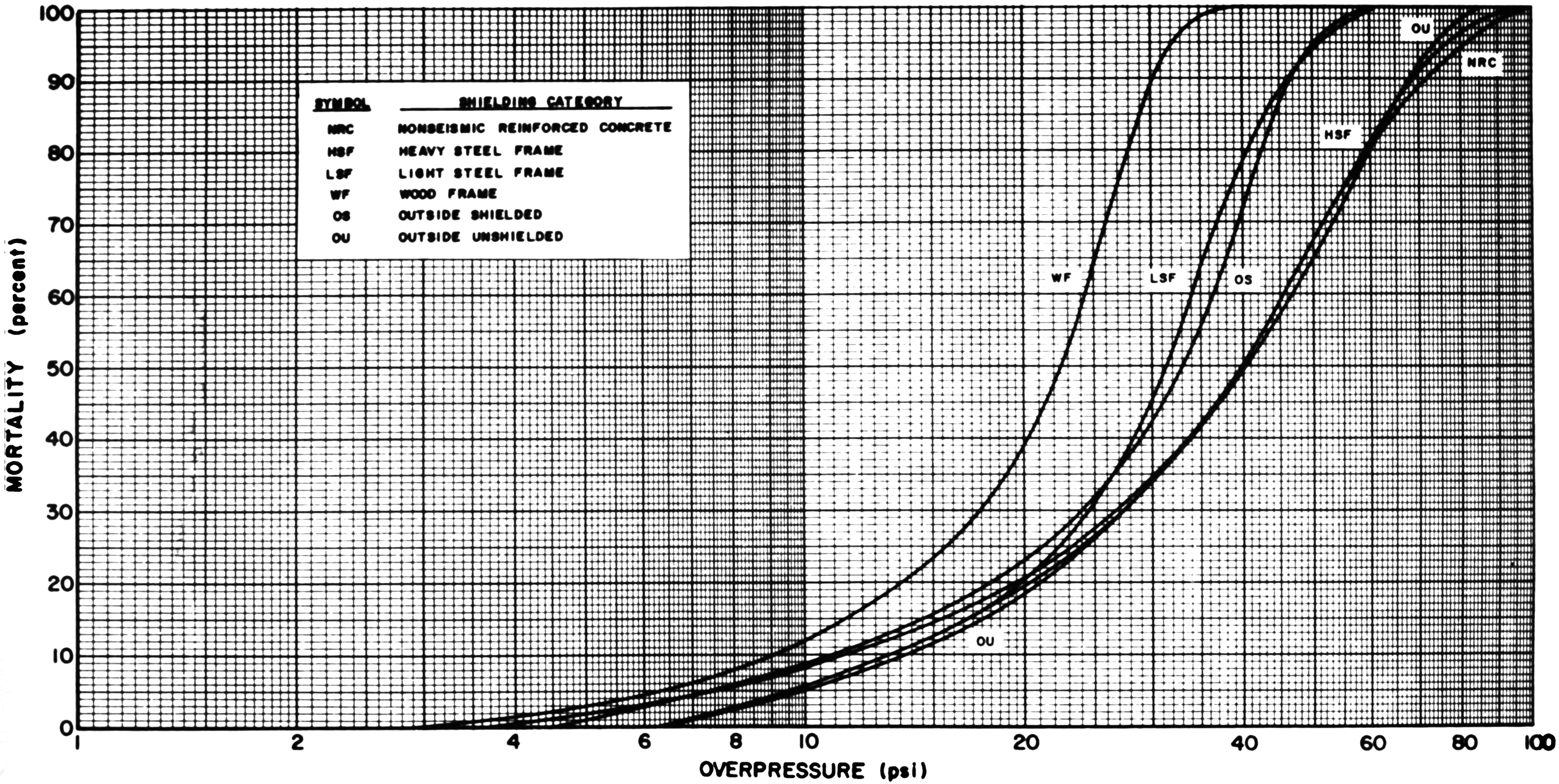


FIG. 4

BLAST MORTALITY CURVES FOR PERSONS IN OR SHIELDED BY STRUCTURES

(12.5-kt SURFACE BURST)

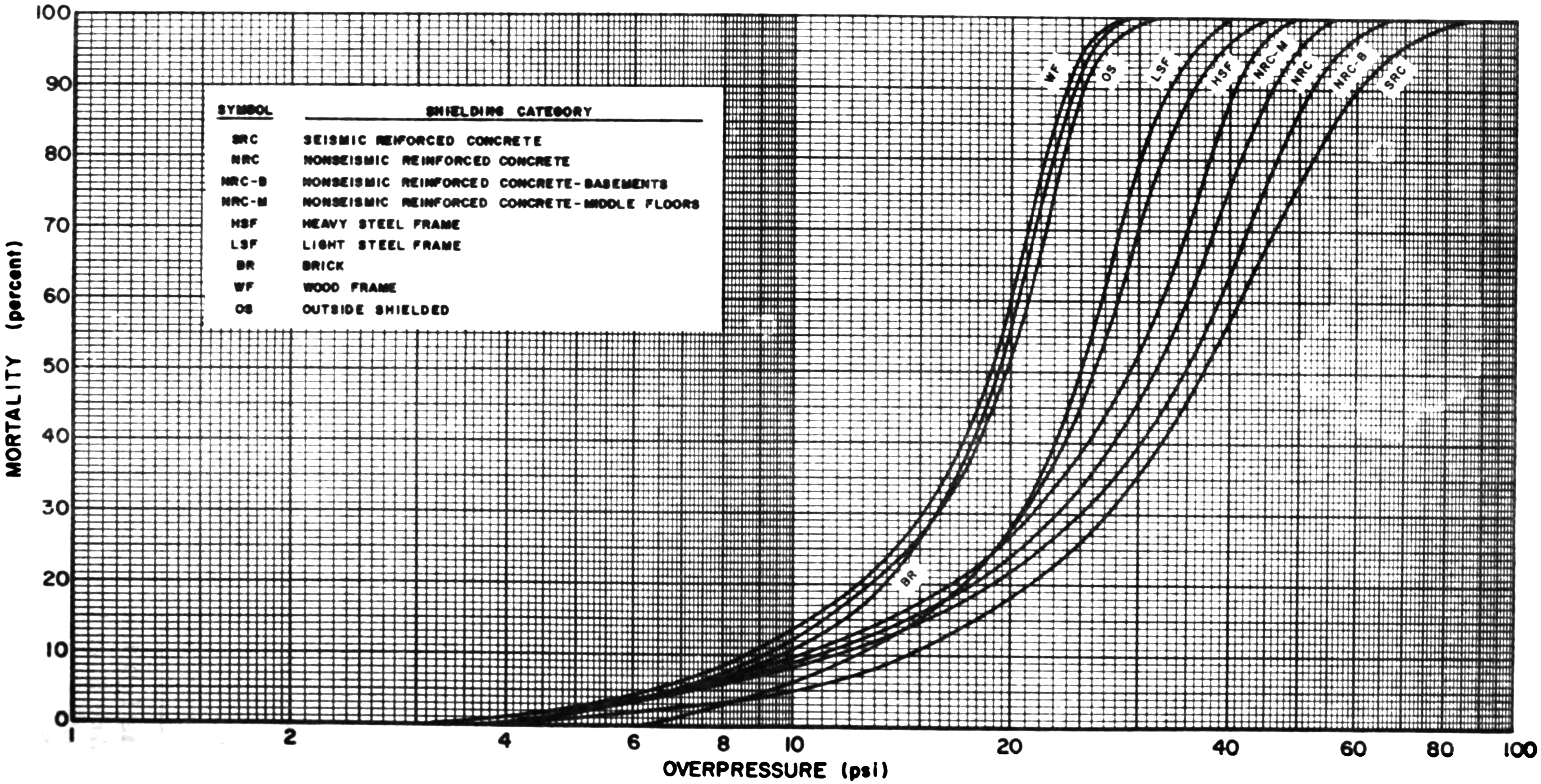


FIG. 7

TOTAL MORTALITY CURVES

FOR NONSEISMIC REINFORCED-CONCRETE BUILDINGS FROM SURFACE BURSTS

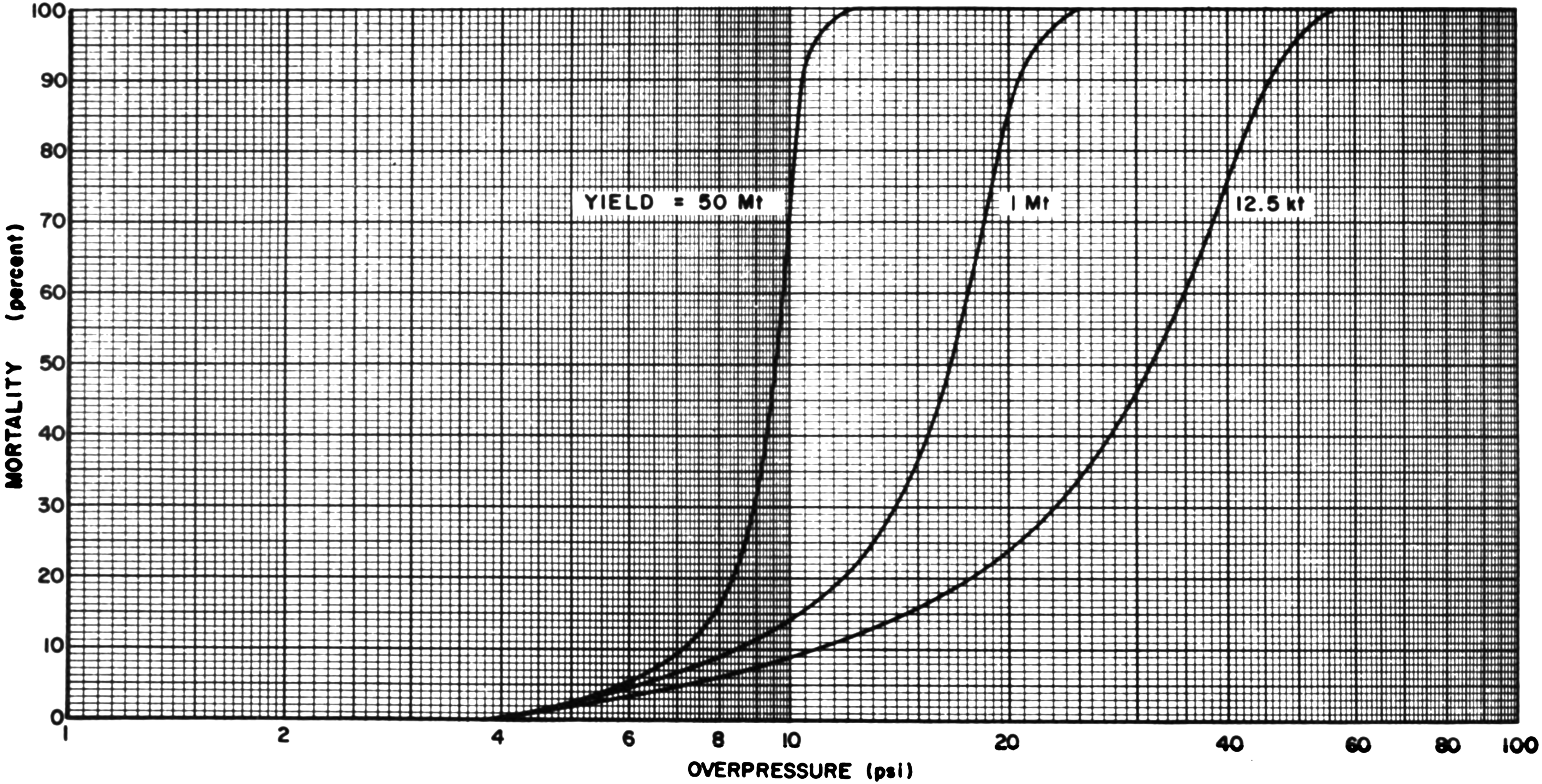
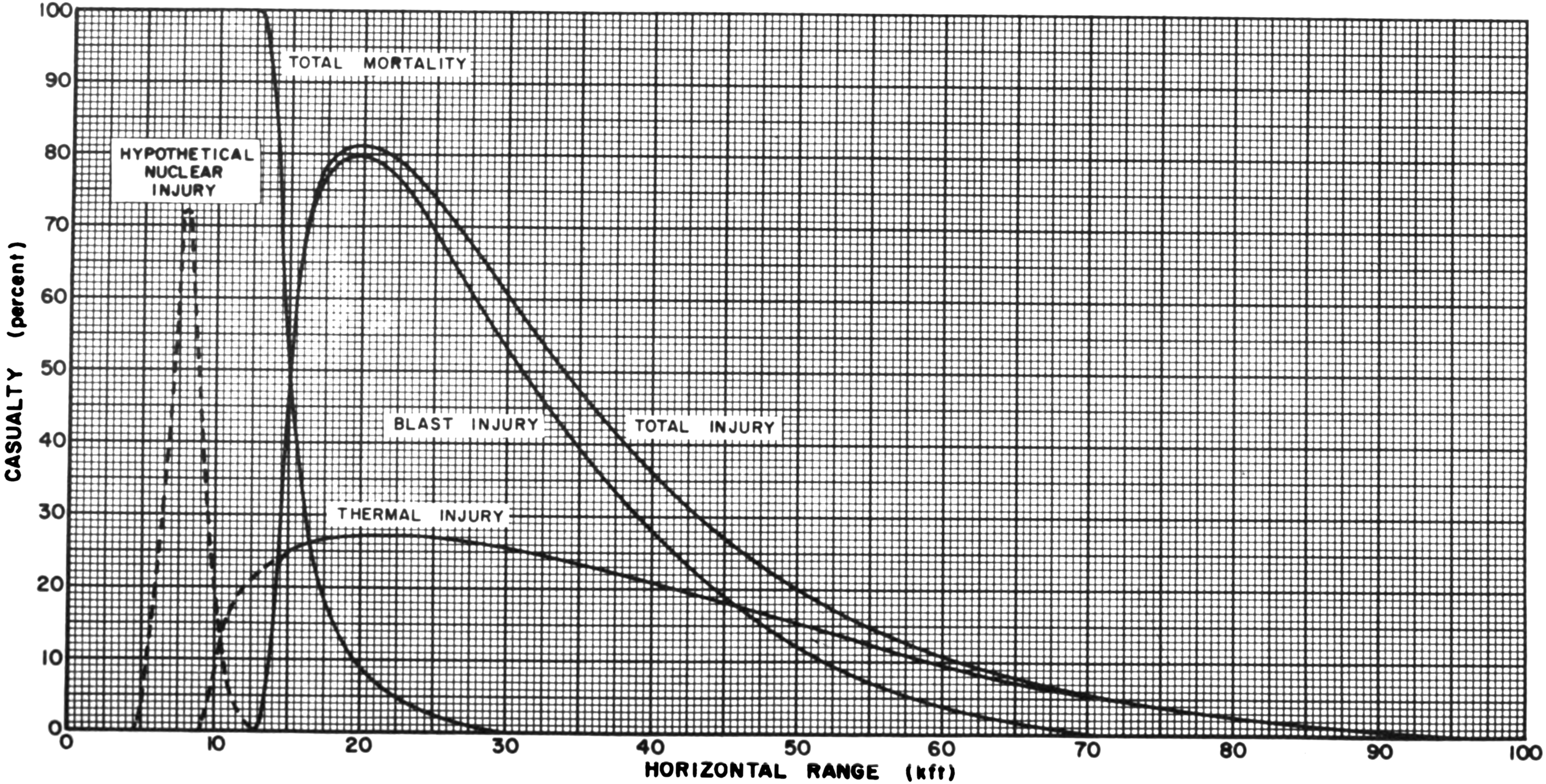


FIG. 10

CASUALTY CURVES VERSUS RANGE FOR NONSEISMIC REINFORCED-CONCRETE BUILDINGS

(5-MT SURFACE BURST)



III. PROMPT-THERMAL CASUALTIES FOR OUTSIDE-UNSHIELDED PERSONS

A. PROMPT-THERMAL MORTALITY CURVE FOR OUTSIDE-UNSHIELDED PERSONS

This curve was much easier to develop than the blast mortality curves (complicated by the effects of the initial-nuclear radiation in Japan) since the prompt-thermal radiation producing flash burns was the dominant effect in Japan as well as for high yields for outside-unshielded persons. Since the predictions of the prompt-thermal exposures in Nagasaki did not correlate well with the burns received, apparently caused by problems in determining the transmissivity, only the new Hiroshima data were used to draw the prompt-thermal mortality curve given in Fig. 19 as a function of the prompt-thermal exposure (cal/cm^2) for the 12.5-kt reference burst. This curve, which is also equivalent to the total mortality curve, can be scaled to higher yields according to the method to be described shortly.

B. PROMPT-THERMAL INJURY CURVE FOR OUTSIDE-UNSHIELDED PERSONS

Before drawing the curves for the <u>surviving</u> injured, all of the data from Hiroshima and Nagasaki were replotted as a function of the appropriate weapons effects levels (cal/cm^2 for prompt-thermal injuries). However, the Hiroshima results were considered to be more reliable than the Nagasaki results for prompt-thermal injuries.

FIG. 19

PROMPT-THERMAL CASUALTY CURVES FROM A 12.5-KT SURFACE BURST FOR OUTSIDE-UNSHIELDED PERSONS

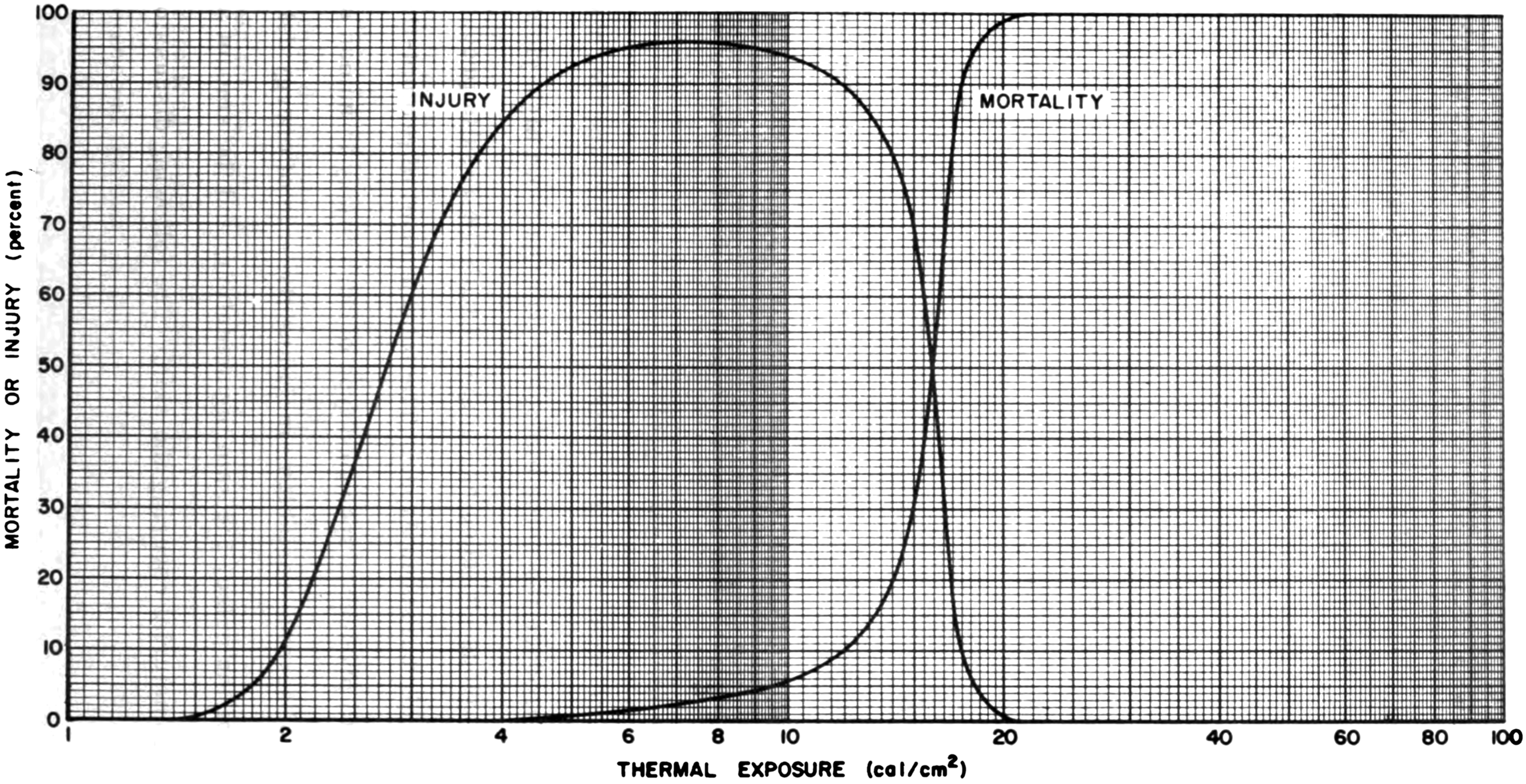
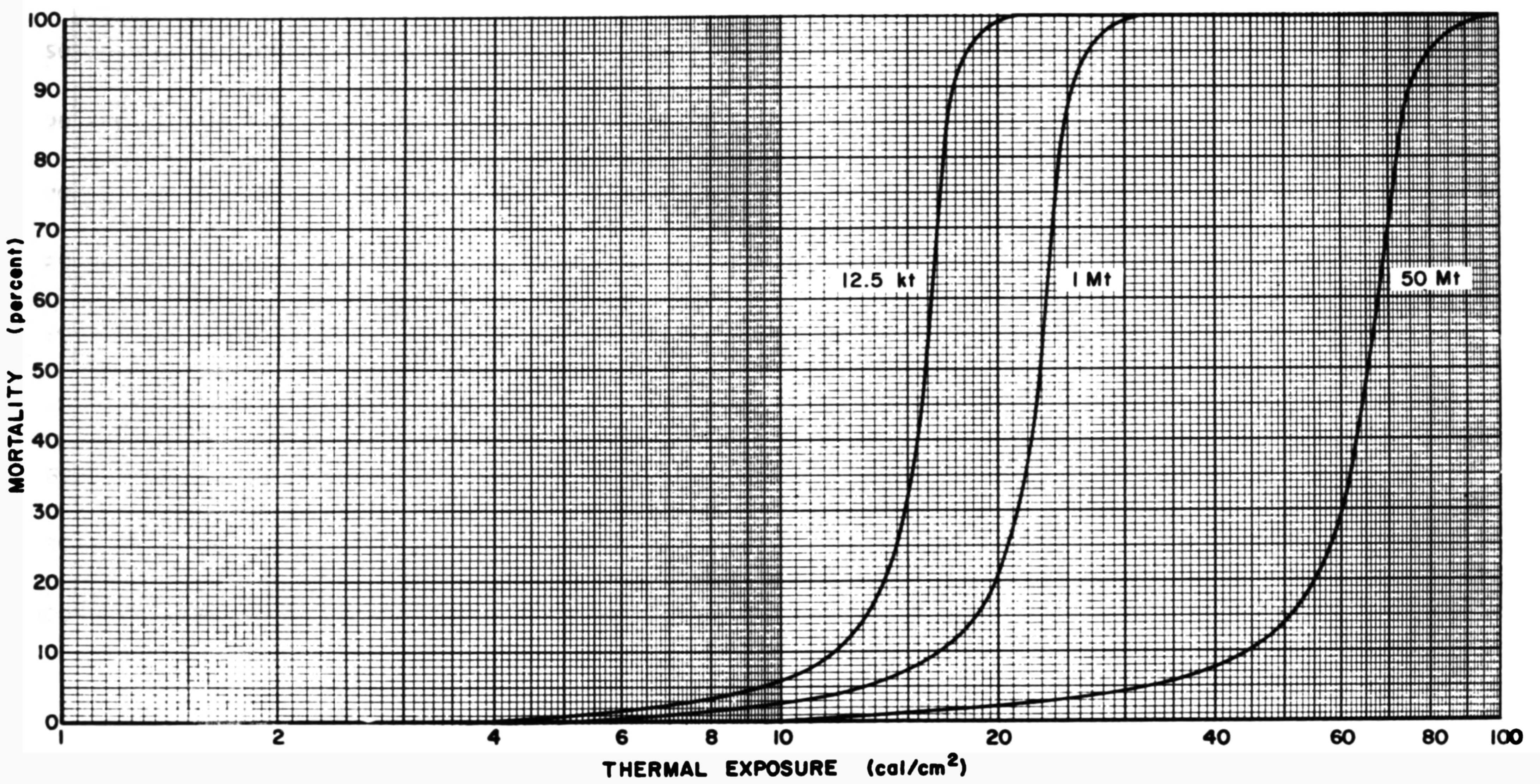


FIG. 24

PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS FOR OUTSIDE-UNSHIELDED PERSONS



condition for development of firestorms. High ambient winds usually cause conflagrations to develop, as noted above.

B. FIRE MORTALITY CURVES

Fires in nine German cities were analyzed in detail to provide data for the development of fire mortality curves. Similar procedures were applied to the fires caused by the nuclear detonation over Hiroshima. Earlier work in this area indicated a correlation between the peak power density (maximum rate of energy release per unit area of the fire bed) and the percent fire mortality for the population at hazard within the fire area.* The four general groupings of construction or shielding categories given by the curves in Fig. 30 are the result of investigating this correlation (Refs. 14 through 18). The general groupings and breakdowns by shielding category are given below:

1) Heavy Construction
   a) Seismic Reinforced-Concrete Buildings
   b) Nonseismic Reinforced-Concrete Buildings (Basements)

2) Medium Construction
   a) Nonseismic Reinforced-Concrete Buildings (Above Ground)
   b) Heavy Steel-Frame Buildings (Basements)†
   c) Light Steel-Frame Buildings (Basements)†
   d) Heavy Brick Wall-Bearing Buildings (Basements)†

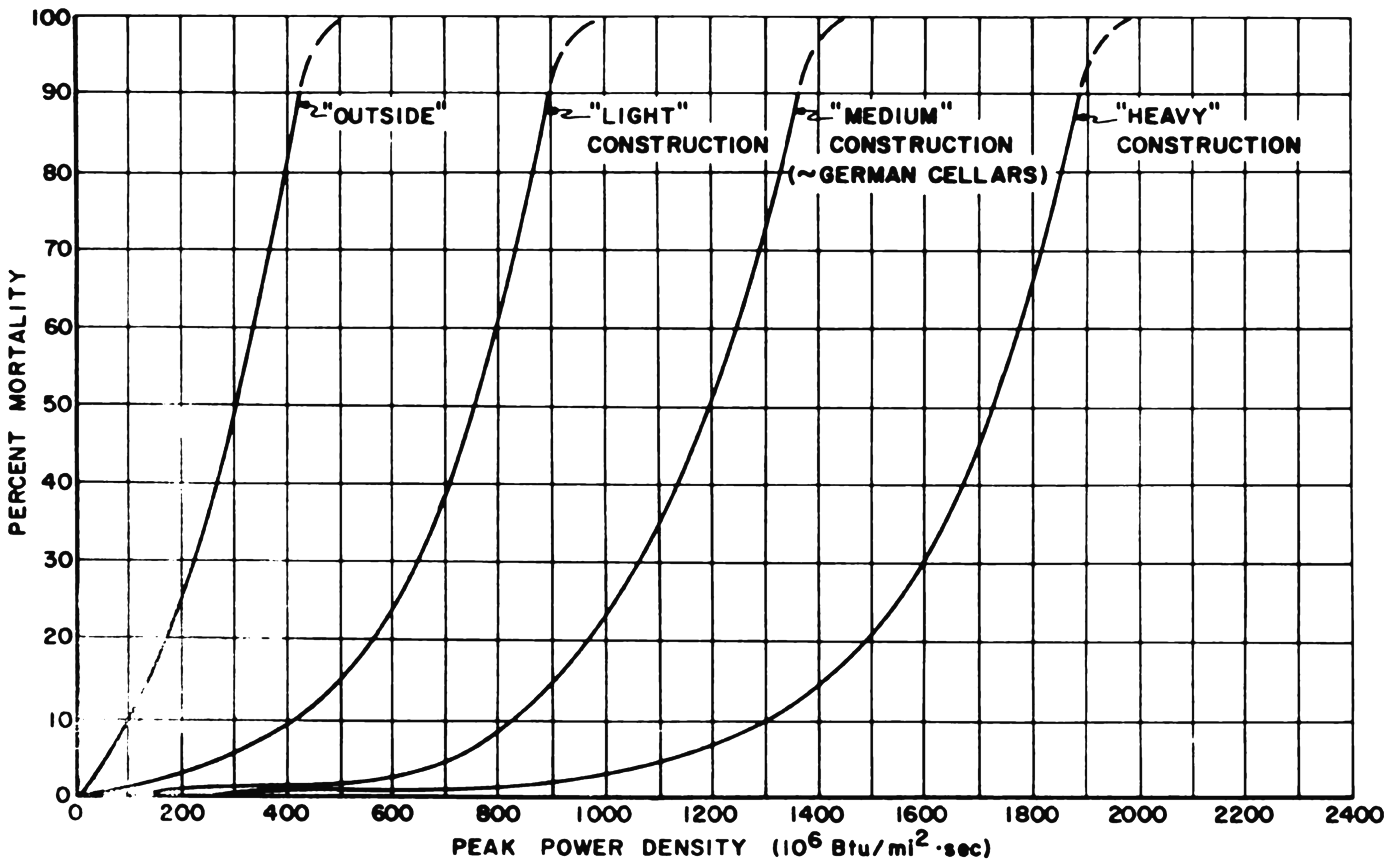
---

*For application of an earlier form of these relationships to historical cases, see Ref. 13.

†If basements are unavailable, this mortality curve probably lies midway between those for medium and light construction.

FIG. 30

FIRE MORTALITY CURVES



3) Light Construction

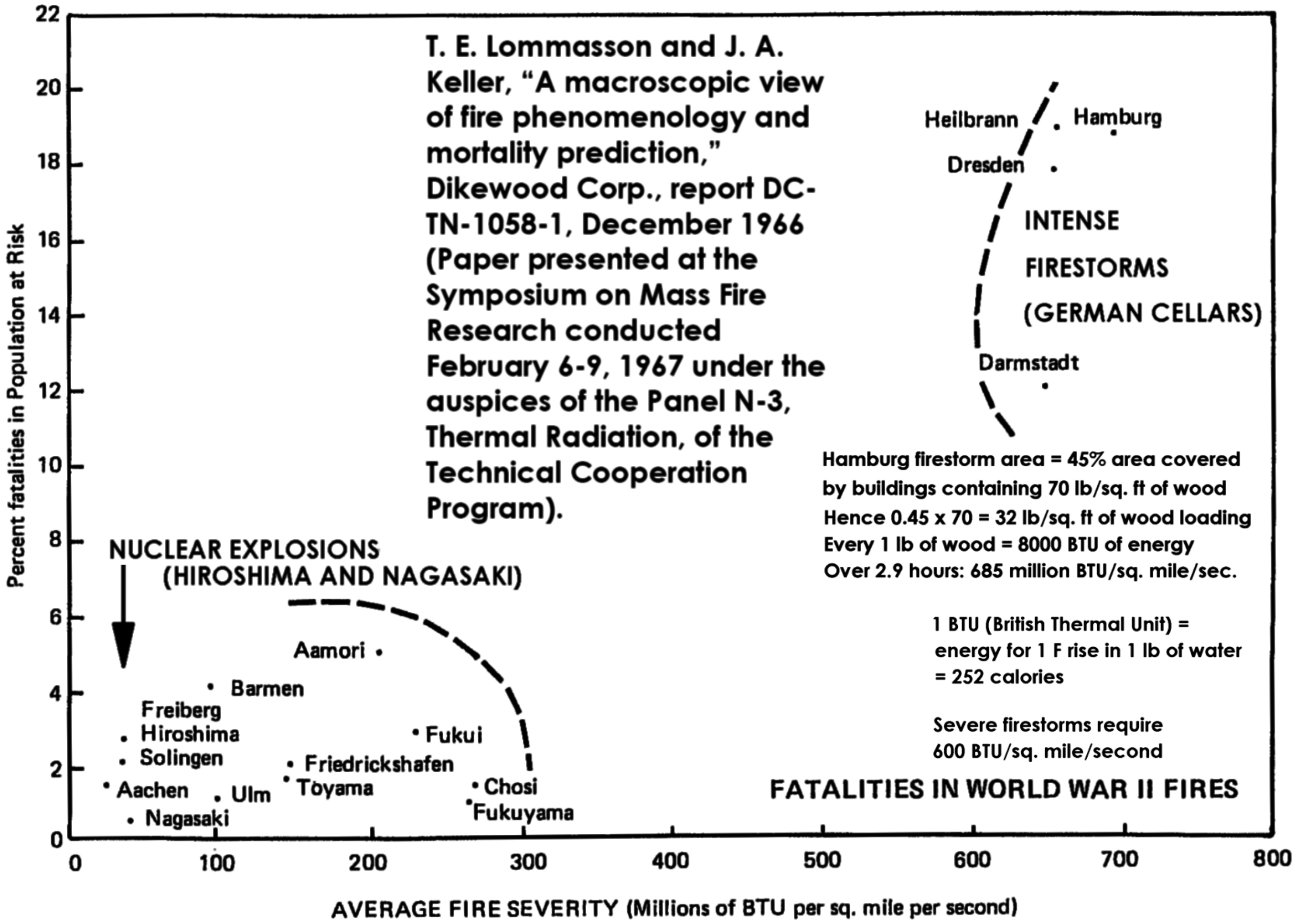
a) Brick Residential Buildings

b) Wood-Frame Buildings (Basements)*

4) Outside

a) Outside-Shielded Category

b) Outside-Unshielded Category



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T. E. Lommasson and J. A. Keller, A Macroscopic View of Fire Phenomenology and Mortality Prediction, Proceedings of the Tripartite Technical Cooperation Program, Mass Fire Research Symposium of the Defense Atomic Support Agency, The Dikewood Corporation; October, 1967.

---

*If basements are unavailable, this mortality curve probably lies midway between those for light construction and the outside category.
between those for medium and light construction.

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Editorial Comments

If clothing ignites, education should be so thorough that the immediate reaction is "smother the flames."

Every child should be trained to roll on the floor if his clothes catch fire, and every adult should know how to extinguish flames with the nearest material at hand - his own coat, a rug, or a blanket. They should know, in advance of the actual emergency, the importance of bringing the coat (or whatever else they are using) across the face to fend the flames and smoke away from the vital air passages.

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Dr. Edward L. Alpen (U. S. Naval Radiological Defense Laboratory): About this question of the spectral dependence of radiant energy, I think Dr. Haynes may have given you the impression that white light does the trick. There is later work which tends to refute that. The work done at Virginia used cut-off filters. The effectiveness of all energy above a certain wave length or below a certain wave length was measured. At the upper end the most effective and the least effective were mixed together and made it appear that infrared was not too good in producing burns. When you subdivide the spectrum, the most effective energy in producing a flash burn is the infrared above about 1.2 microns.

The importance of this, and the only reason I make an issue of it, is that a very important source of flash burn, both in civilian life and under wartime disaster conditions, is radiant energy burns from flaming sources. We have done a great deal of research on this subject for the U. S. Forest Service, because radiant energy burns are important in forest fires.

Energy in the wave lengths of 0.6 to 0.8 micron is about one-eighth as destructive as the rest of the spectrum. But long wave length radiation above one micron is extremely destructive, and the most effective of all.

49

Dr. Alpen: Anything that shields out radiation above one micron is extremely effective in preventing burns to the skin.

50

THE BURN SURFACE AS A PARASITE

WATER LOSS, CALORIC DEMANDS, AND THERAPEUTIC IMPLICATIONS

Carl Jelenko, III, M.D.

Department of Surgery

University of Maryland School of Medicine and Hospital

Baltimore, Maryland

Water is Lost through Burned Skin*

A burn may be thought of as a parasite, drawing from its host water, protein, and other substances which the host needs for its survival. An uninjured person who is not perspiring may lose from 1.15 to 2.0 quarts of fluid a day through his lungs and skin,[1,2,4,5,14] depending on the temperature of his environment. The fluid losses from a burn wound are far in excess of those from intact skin and may amount to 2 gallons per day, or more if the burn is large enough.[2,5,6,17,21] If, during the first 48 hours after injury, no more fluid is given to an extensively burned patient than he would need in health, the uncompensated loss of fluid from his circulation may cause shock, and if sufficiently severe, death. After the first 48 hours, the danger of shock is lessened, but inordinate fluid losses will continue from the burn surface.

Heat is Lost Necessitating a High Food Intake

To make matters worse, evaporation of moisture from the wound surface saps not only the body's water stores but its energy stores as well. When water evaporates from the burned surface, cooling results and the body loses heat. The larger the burn wound, the more water loss and the more heat or energy loss.**

*The majority of the paragraph headings in this article were supplied by the editors.

**Although the core temperature of the human body approximates 39.5°C, the body surface averages only 32°C. At any given temperature, water can be evaporated by applying a certain number of heat calories. At 32°C, one gram of water can be evaporated if 0.579 large calories of heat is invested.

How Can the Fluid and Heat Losses Be Diminished?

Unfortunately, we do not possess at present any practical means of reducing the loss of water from a burn to the level of loss from intact skin on a scale suitable for use following a holocaust.

Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP (American College of Emergency Physicians) News
http://www.acep.org/content.aspx?id=40462

August 2008
By Patrice Wendling
Elsevier Global Medical News

CHICAGO - Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit.

The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

"Virtually every ambulance in Iowa has a roll of plastic wrap in the back," Mr. Clopton said in an interview. "We just wanted to get the word out about the success we've had using plastic wrap for burn wounds," he said.

Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it's inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

"I can't recall a single incident of its causing trouble for the patients," Dr. Kealey said. "We started using it as an answer to the problem of how to create a field dressing that met those criteria. I suppose that the use of plastic wrap has spread from here out to the rest of our referral base."

Although protocols vary between different localities, plastic wrap is typically used for partial- and full-thickness thermal burns, but not superficial or chemical burns. It is applied in a single layer directly to the wound surface without ointment or dressing under the plastic and then secured loosely with roller gauze, as needed.

Because plastic wrap is extruded at temperatures in excess of 150° C, it is sterile as manufactured and handled in such a way that there is minimal opportunity for contamination before it is unrolled for use, said Mr. Clopton of the emergency care unit at Mercy Hospital, Iowa City. However, it's best to unwind and discard the outermost layer of plastic from the roll to expose a clean surface.

SECRET—GUARD

ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

DEPARTMENT OF ATOMIC ENERGY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT
(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE
(Monte Bello Islands, Australia—October, 1952)

DIRECTOR'S REPORT

Summary

This report summarises data on the external effects observed in the trial of the first British atomic weapon, which was exploded under conditions representing a ship-borne attack on a port.

Briefly, it may be said, in reviewing the general physical effects, that the air blast and gamma flash effects were comparable with those for an air burst but the thermal radiation effects were very much less. The underwater shock was much less than that from an underwater burst. Some general information on the residual contamination is given, but data on the extent of the contamination forms the subject of a separate section not generally available.

The report describes the conditions under which the trial was conducted, the measurements made of the physical phenomena produced by the detonation of the weapon, and gives brief descriptions of the results.

Information is given concerning the behaviour of Anderson shelters, of certain reinforced concrete cubicles, of a model ship's funnel, of a compartment representing a deckhouse, and various aircraft components. Data are also given for the penetration of gamma rays into slit trenches, concrete cubicles and Anderson shelters; for the effect of thermal radiation on various materials and service equipment; and for possible contamination (and decontamination) of personnel, equipment, ships and food stored in open dumps. The report also includes the results of experiments on the absorption of radio-elements by biological systems.

Regraded by A.W.R.E. on ....10-1-61......

From SECRET ATOMIC GUARD

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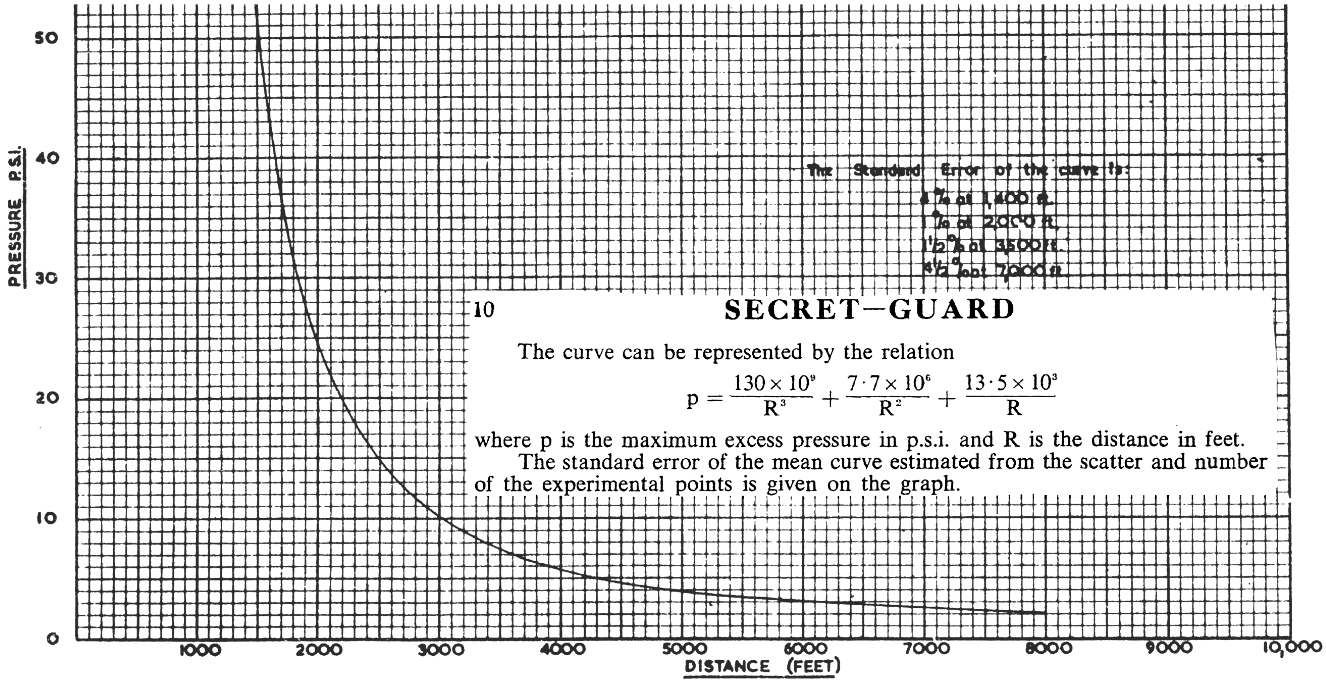

10 **SECRET—GUARD**

The curve can be represented by the relation

$$p = \frac{130 \times 10^9}{R^3} + \frac{7 \cdot 7 \times 10^6}{R^2} + \frac{13 \cdot 5 \times 10^3}{R}$$

where p is the maximum excess pressure in p.s.i. and R is the distance in feet.

The standard error of the mean curve estimated from the scatter and number of the experimental points is given on the graph.

25 kt nuclear trial (Monte Bello, 3 October 1952)

Fig. 12.1, Andersons at 1380 ft range from bomb ship shown in the photo, moored 400 yards off shore.

Left: Fig. 12.3, Andersons at 1800 ft after burst. Right: Fig. 12.4, Andersons protected by blast walls at 2760 ft.

SANDBAGS GIVE
NO "EARTH ARCHING"
PROTECTION
(WORST CASE)

12. Blast Effects

12.1. *Blast Damage to Anderson Shelters*

12.1.1. In accordance with certain requirements of the Chief Scientific Adviser to the Home Office, fifteen Anderson shelters were erected, three at each of five sites situated, on Trimouille Island, more or less due West of the explosion at distances of 1,380, 1,530, 1,800, 2,760 and 3,390 feet. In each group one shelter was placed with its entrance facing the explosion, one with the entrance facing away from the explosion and one sideways to it.

The shelters were erected with a blast wall shielding the entrance, by the normal procedure laid down by the Ministry of Works, there being a difference from the usual practice in this country in that the covering of the shelter and the filling of the blast wall, instead of being earth, consisted of sandbags filled with fine dune sand, the only material available. The shelters were sunk with their floors about 4 feet below ground level; the thickness of the sandbags averaged 18 inches directly over the top of the roof arch to about 3 ft. 6 ins. at ground level at the sides. The blast wall was from 2 ft. to 2 ft. 6 ins. thick contained within sheets of corrugated iron and was placed about 3 feet from the shelter.

12.1.2. In the groups of shelters at 1,380, 1,530 and 1,800 feet, the sandbags covering them were almost entirely blown away and the blast walls were destroyed.

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

At 2,760 feet, Fig. 12.4, some of the sandbags covering the shelters were displaced and the blast walls were distorted whilst at 3,390 feet, Fig. 12.5, the effect was quite small. At these distances, the shelters were not in direct view of the explosion owing to intervening sandhills.

13. The Penetration of the Gamma Flash

13.1. *Experiments on the Protection from the Gamma Flash afforded by Slit Trenches*

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

Table 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

Type of trench	Rectangular broadside-on open			Rectangular end-on open	Circular open		Rectangular broadside-on covered	
Distance (yards) ...	1,300	943	733	1,300	1,300	943	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	300	3,000	3,000	14,000
Depth below ground level (inches)								
6 ...	150	1,000	—	230	214	1,200	(75)	—
12 ...	75	430	—	150	120	545	47·6	—
24 ...	33·3	150	584	60	54·5	188	25	(140)
36 ...	23	70	216	31·6	30	86	13	(56)
48 ...	(20)	43	100	20	17·7	48·5	7·7	(31)
60 ...	—	(37·5)	61	13·6	10·7	(33·3)	5	(23)
72 ...	—	—	(46·7)	(8·6)	7	—	(3·5)	—

Entries in brackets are extrapolations or estimates.

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AWRE - T1/53

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MINISTRY OF SUPPLY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

REPORT No. T 1/53
(HURRICANE)

B.0134

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BY AWE ALDERMASTON

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A.W.R.E.
Aldermaston Berks.

[redacted]

May, 1953

3.2 Blast Damage

3.2.1 Anderson Shelters

Standard Anderson Shelters, with sandbag covering and blast wall construction were locat.d at 460, 510, 600, 920 and 1,130 yards from ground zero. Mean blast pressures, in pounds/sq. inch, recorded inside the shelters are shown in the following table.

Distance (yds.)	Presentation		
	Front	Side	Rear
460	NR	NR	NR
510	38	27	40
600	28	21	28
920	16	7	14
1130	8.5	4	5.5

Front presentation implies blast wall facing towards event.
Rear " " " " " away from event.
Side " " shelter side on to event.

Shelters at 460, 510 and 600 yards suffered damage including demolition of blast walls, removal of sandbag covering and some displacement of the corrugated iron.

At 920 and 1,130 yards the shelters suffered relatively little damage.

Civil defence authorities consider that there might have been some 50% survival from blast damage of personnel in shelters at 460 yards and some 90 per cent at 600 yards, fatal casualties being mainly due to secondary blast effects (e.g. debris) and not to direct effects on the person of the blast pressure itself. The front presentation appears the most hazardous, due to the collapse of the blast wall into the shelter. At such distances, however, the survival from the effects of gamma flash would have been virtually nil. (MORE EARTH COVER IS NEEDED FOR RADIATION.)

At 920 and 1,130 yards there would have been no casualties from blast, and incidentally, little risk from the effect of gamma flash.

NUMBER AND CLASSIFICATION OF OFFICIAL EVACUEES IN GREAT BRITAIN IN 1939 AND 1940

900,000 of the 1.5 million returned to the target areas after four months of war.	SEPTEMBER, 1939		JANUARY, 1940	
	Number	Percentage Distribution	Number	Per cent of Those in September, 1939
1. Unaccompanied school children	826,959	56.1	457,600	55
2. Mothers and accompanied children	523,670	35.5	64,900	12
3. Expectant mothers	12,705	0.9	1,140	9
4. Blind persons, cripples, and other special classes	7,057	0.5	2,440	35
5. Teachers and helpers	103,000	7.0	46,500	45
Total	1,473,391	100.0	572,580	39

Source: R. M. Titmuss, *Problems of Social Policy* (London: H.M. Stationery Office, 1950), pp. 103 and 172.

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ORO Log No. 56656

HOME DEFENSE DIVISION
PASSIVE DEFENSE GROUP
Report ORO-R-17, Appendix B
Published December 1956

Effectiveness of Some Civil Defense Actions in Protecting Urban Populations (u)

Appendix B of Defense of the US against Attack by Aircraft and Missiles (u)

by

John Balloch

Annex A *by* G. Trevor Williams
Annex B *by* Oscar Sutermeister

Authorized by

Ellis A. Johnson
Director

ORO
OPERATIONS RESEARCH OFFICE
The Johns Hopkins University Chevy Chase, Maryland

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LETHAL RANGE

The mortality coefficients vs distance of a 10-Mt weapon as used in this study are presented in Fig. 9. For comparison, mortality vs distance curves as used by the FCDA and SRI are also presented. All three curves are based essentially on Hiroshima-Nagasaki data and have been modified to account for the longer positive-pulse phase associated with

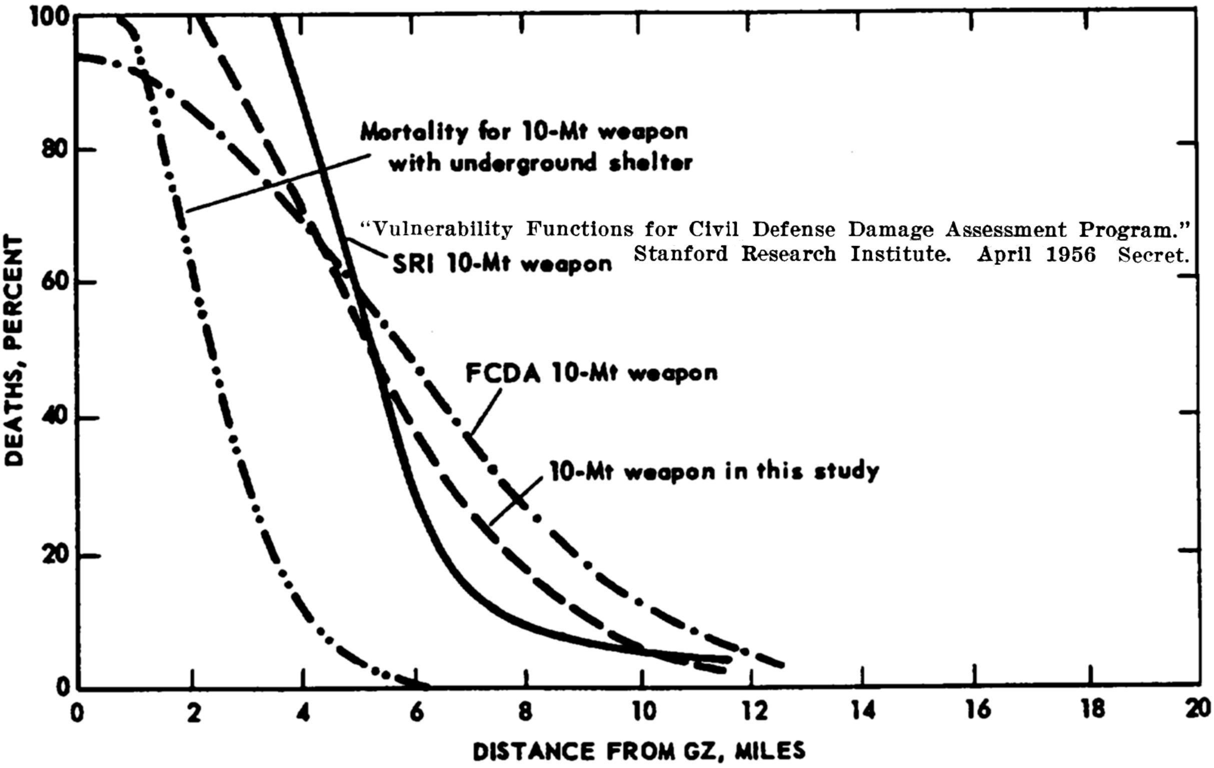


Fig. 9 — Population Lethality Contours for 10-Mt Ground Burst

high-yield weapons. The curve used in this study was the best approximation to Hiroshima data that would meet the purposes of the study; like the SRI curve it has a region of 100 percent mortality to meet the requirements of cratering associated with ground bursts.

Figure 9 also gives the mortality coefficients for populations in shelters with 3 ft of earth cover.

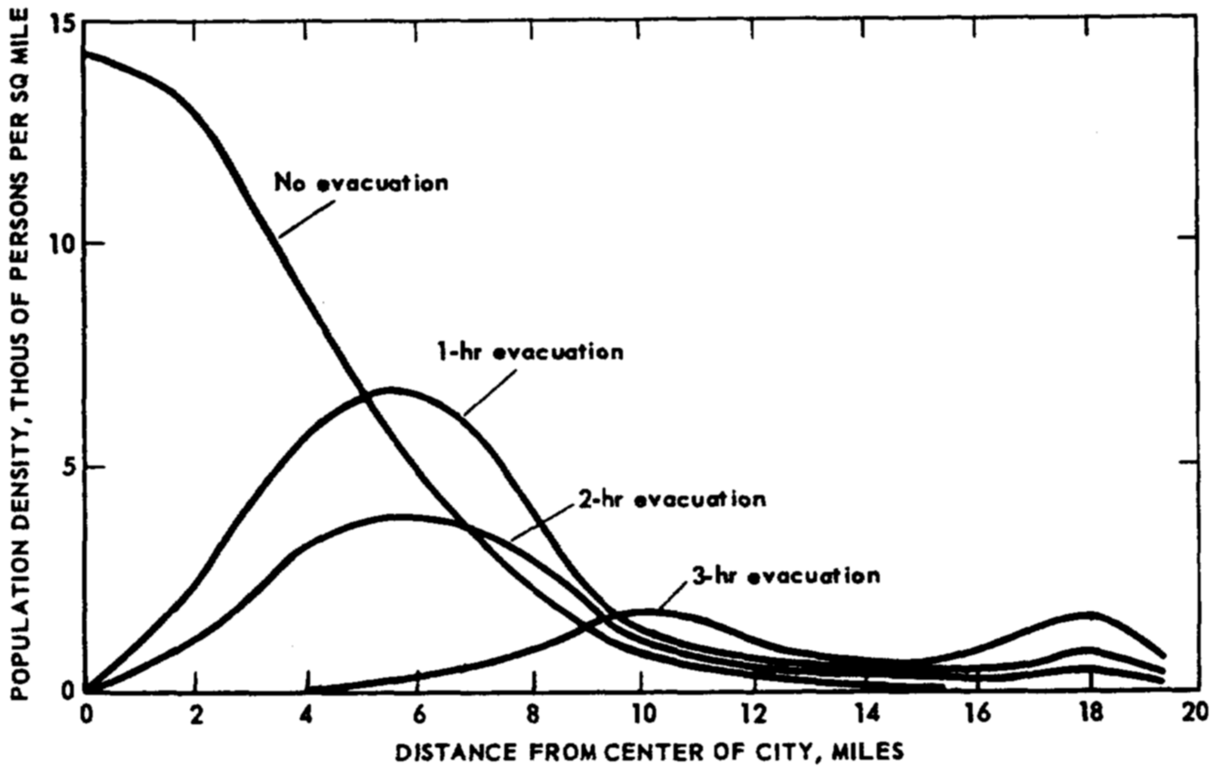


Fig. 10 — Population Density of Washington Target as Function of Distance from Center of City for Three Evacuation Times

HOME OFFICE

CIVIL DEFENCE

Manual of Basic Training

VOLUME II

BASIC METHODS OF PROTECTION AGAINST HIGH EXPLOSIVE MISSILES

PAMPHLET No 5

LONDON: HIS MAJESTY'S STATIONERY OFFICE
1949

SIXPENCE NET

Domestic Shelters (for household use)

(*a*) ANDERSON SHELTER. This shelter was designed for erection outside the house. It consisted of 14 gauge corrugated steel sheets, steel angles, ties and channel irons. It was normally sunk about 3 ft. into the ground and covered over with earth to a minimum depth of 15 in., which, with the 14 gauge corrugated sheet gives the equivalent of 18 in. of earth.

The standard shelter was 6 ft. 6 in. by 4 ft. 6 in. by 6 ft. high. It was designed to shelter six persons, but was capable of being lengthened to accommodate eight, ten or twelve persons; or of being shortened to accommodate four persons.

Unless the entrance was screened (within 15 ft.) by a building or existing wall, a screen wall had to be provided. Trouble was sometimes experienced due to flooding by subsoil water in which case the below ground portion was tanked by a lining of cement concrete.

The shelter was, on occasions, erected on the surface, which involved casing it in cement concrete. The result was efficient but expensive.

(*b*) MORRISON SHELTER. This shelter was designed for use in a house and its chief function was to protect the occupants from being crushed by the collapse of the building. Protection against blast and fragments was provided by the walls of the house, which were sometimes specially thickened for this purpose.

It consisted of a steel table measuring 6 ft. 4 in. long by 3 ft. 10½ in. wide. It provided sleeping accommodation for two adults and a child, or a considerable number of small children in a sitting position, when used as a school classroom shelter.

(*c*) STRUTTED REFUGE ROOM—STRUTTED BASEMENT. The object of this form of shelter was the same as the Morrison shelter, i.e. to provide strutting to prevent the collapse of the room and to use the walls as protection against blast and fragments. Strutting was either steel or wood and the design and strength suited to the weight to be supported.

(*d*) SMALL TRENCH OR SMALL SURFACE SHELTER IN GARDEN. This type of shelter needs no special comment.

HOME OFFICE

AIR RAID PRECAUTIONS

DIRECTIONS
FOR THE ERECTION AND SINKING OF THE GALVANISED CORRUGATED STEEL SHELTER

(ANDERSON SHELTER)

February 1939

London family who survived in Anderson shelter during Blitz, when the shelter absorbed the blast (earth was blown off) in 1940

A.R.P. (O) 10

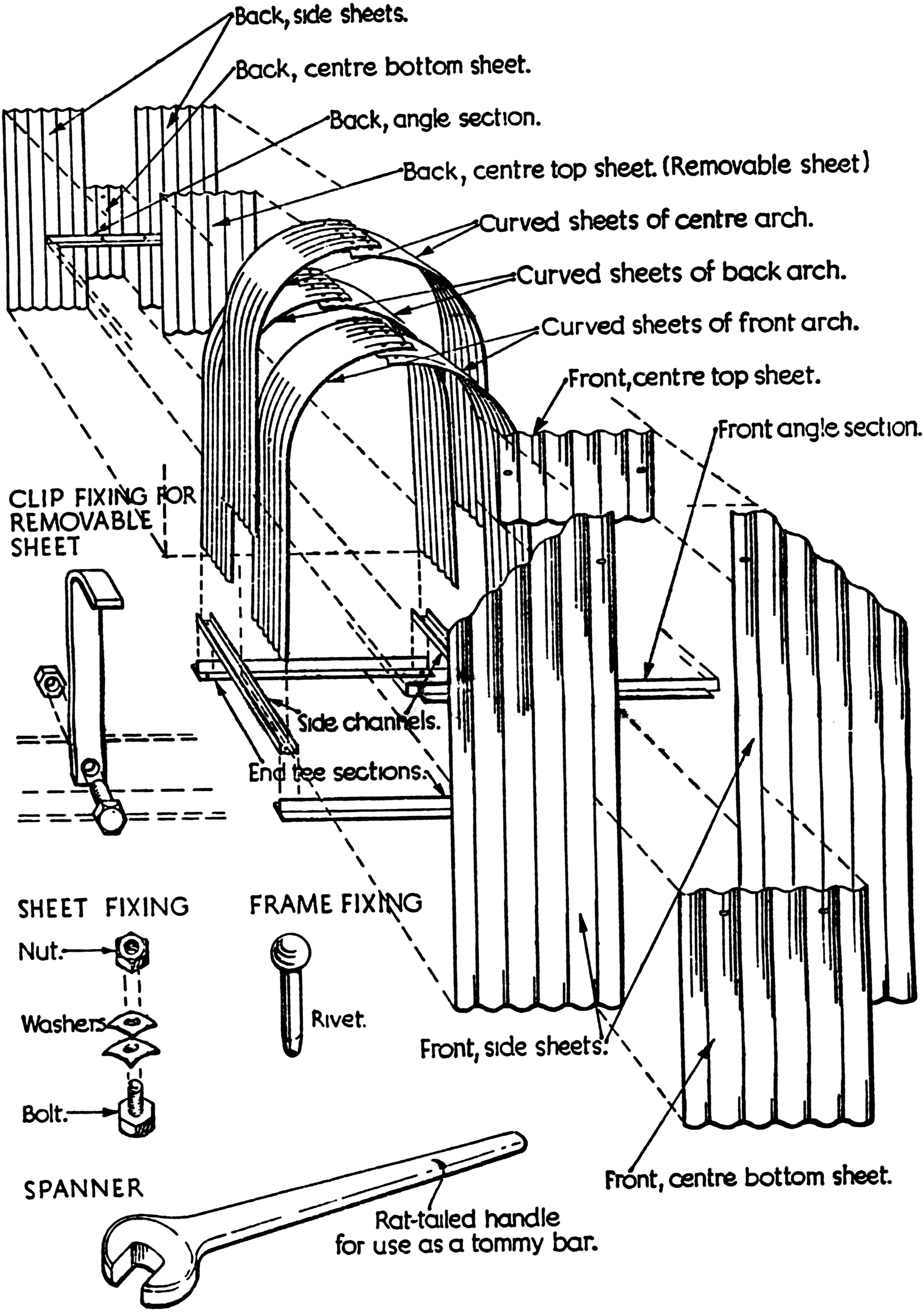


FIG. 3.—THE INDIVIDUAL PARTS.

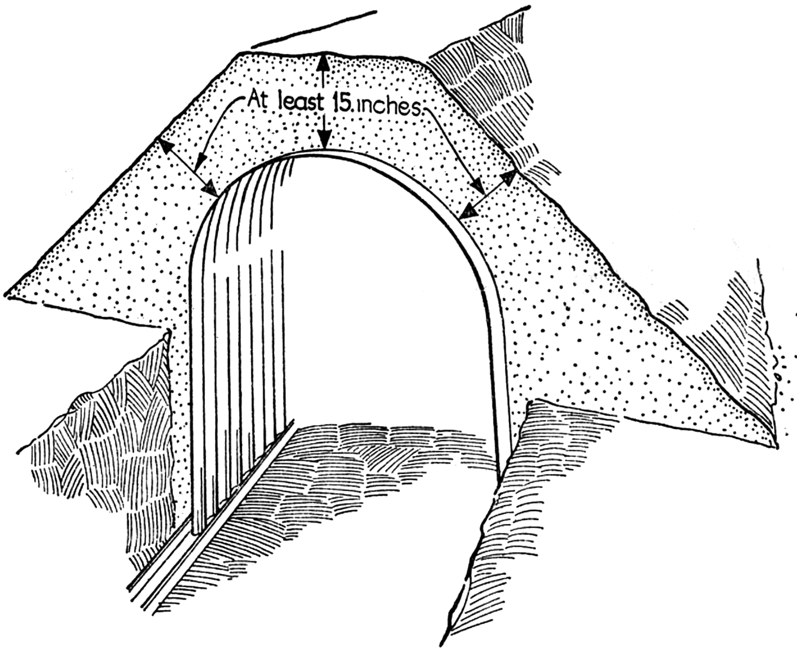


Fig. 4.—Stage 12. Covering the Shelter with Earth.

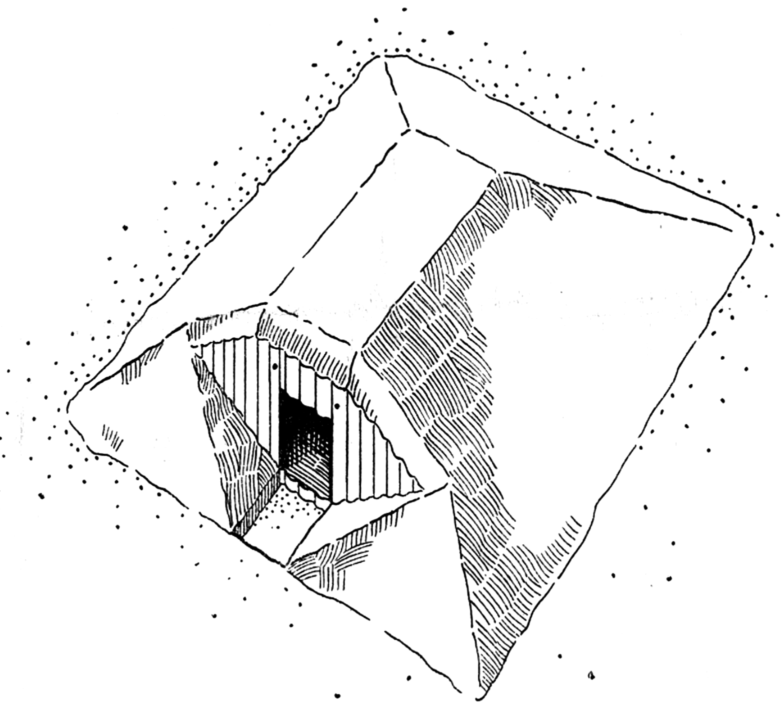


Fig. 4.—Stage 13. The Shelter Complete with Earth Cover.

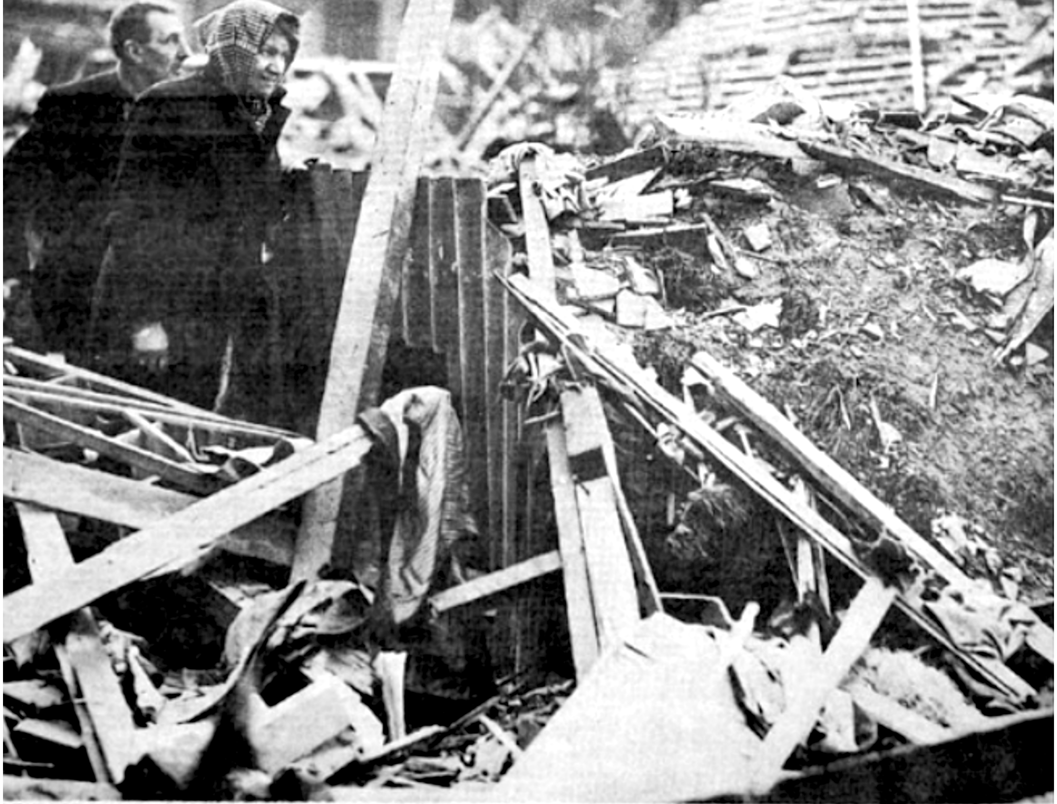
Anderson shelter survives hit: Norwich 27 April 1942

Anderson shelter survives, Croydon, October 1940

And They Came Out of It Alive...

The edge of this bomb crater, 30ft. deep, in a household garden near London, is only 4ft. from the Anderson shelter. But the two people in the shelter during London's six-hour raid—Mrs. Clark and Miss Clark—were unhurt. You see Miss Clark in the picture examining the damage to the structure.

Daily Mirror
28 Aug 1940

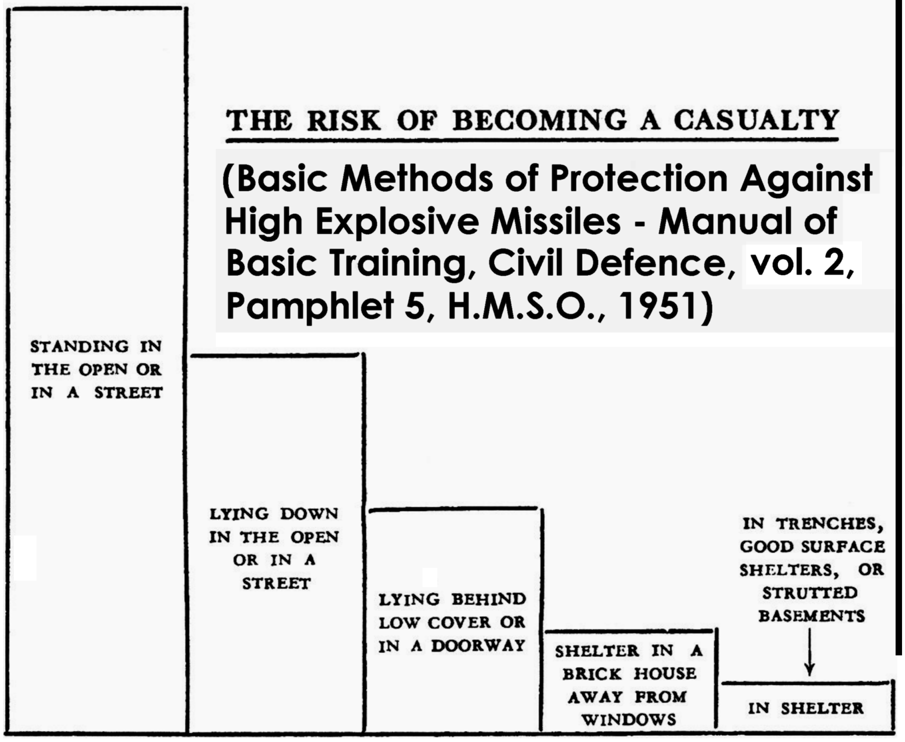


Proof that the Anderson garden shelter could withstand a house collapsing on it can be seen in this picture. Mr. and Mrs. Clague bless their insistence on 'going to ground' when their homes and those of their neighbours were reduced to rubble.

18 June 1941

Anderson shelter survives at Latham Street, Poplar, London, 1941:

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.



THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)

Anderson shelters absorbed the blast energy and were damaged, saving lives.

The Effects of

Nuclear Weapons

SAMUEL GLASSTONE
Editor

Prepared by the

UNITED STATES DEPARTMENT OF DEFENSE

Published by the

UNITED STATES ATOMIC ENERGY COMMISSION

June 1957

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Washington 25, D. C. - Price $2.00 (paper bound)

TABLE 3.11

OVERPRESSURE, DYNAMIC PRESSURE, AND WIND VELOCITY IN AIR AT SEA LEVEL

Peak overpressure (pounds per square inch)	*Peak dynamic pressure (pounds per square inch)*	*Maximum wind velocity (miles per hour)*
72	80	1, 170
50	40	940
30	16	670
20	8	470
10	2	290
5	0. 7	160
2	0. 1	70

3.12 At a given location, the dynamic pressure changes with time in a manner somewhat similar to the change in the overpressure, but the rate of pressure decrease behind the shock front is different. This may be seen from Fig. 3.12 which indicates qualitatively how the two pressures vary in the course of the first second or so following arrival of the shock front.

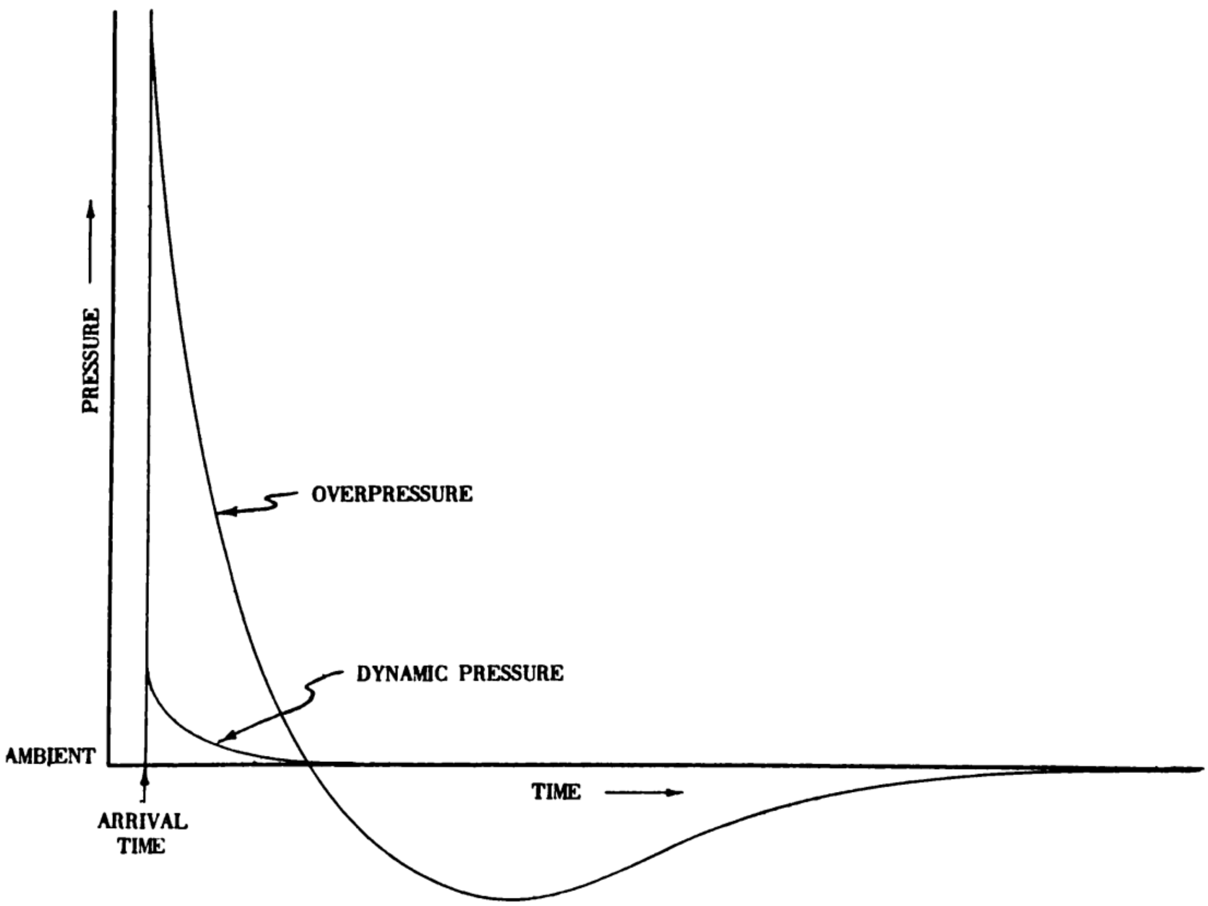


Figure 3.12. Variation of overpressure and dynamic pressure with time at a fixed location.

The curves show the variation of peak overpressure with distance for a 1 KT surface burst and for a 1 KT free-air burst (based on the $2W$ assumption in § 3.94) in a standard sea level atmosphere.

Scaling. For yields other than 1 KT, the range to which a given overpressure extends scales as the cube root of the yield, i. e.,

$$d = d_0 \times W^{1/3},$$

where, for a given overpressure,

d_0 is the distance from the explosion for 1 KT,

and

d is the distance from the explosion for W KT.

Example

Given: A 1 MT surface burst.

Find: The distance to which 2 psi extends.

Solution: From Fig. 3.93 the cube root of 1000 is 10. From Fig. 3.94a, a peak overpressure of 2 psi occurs at a distance of 0.53 mile from a 1 KT surface burst. Therefore, for a 1 MT surface burst,

$$d = d_0 \times W^{1/3} = 0.53 \times 10 = 5.3 \text{ miles.} \quad \textit{Answer}$$

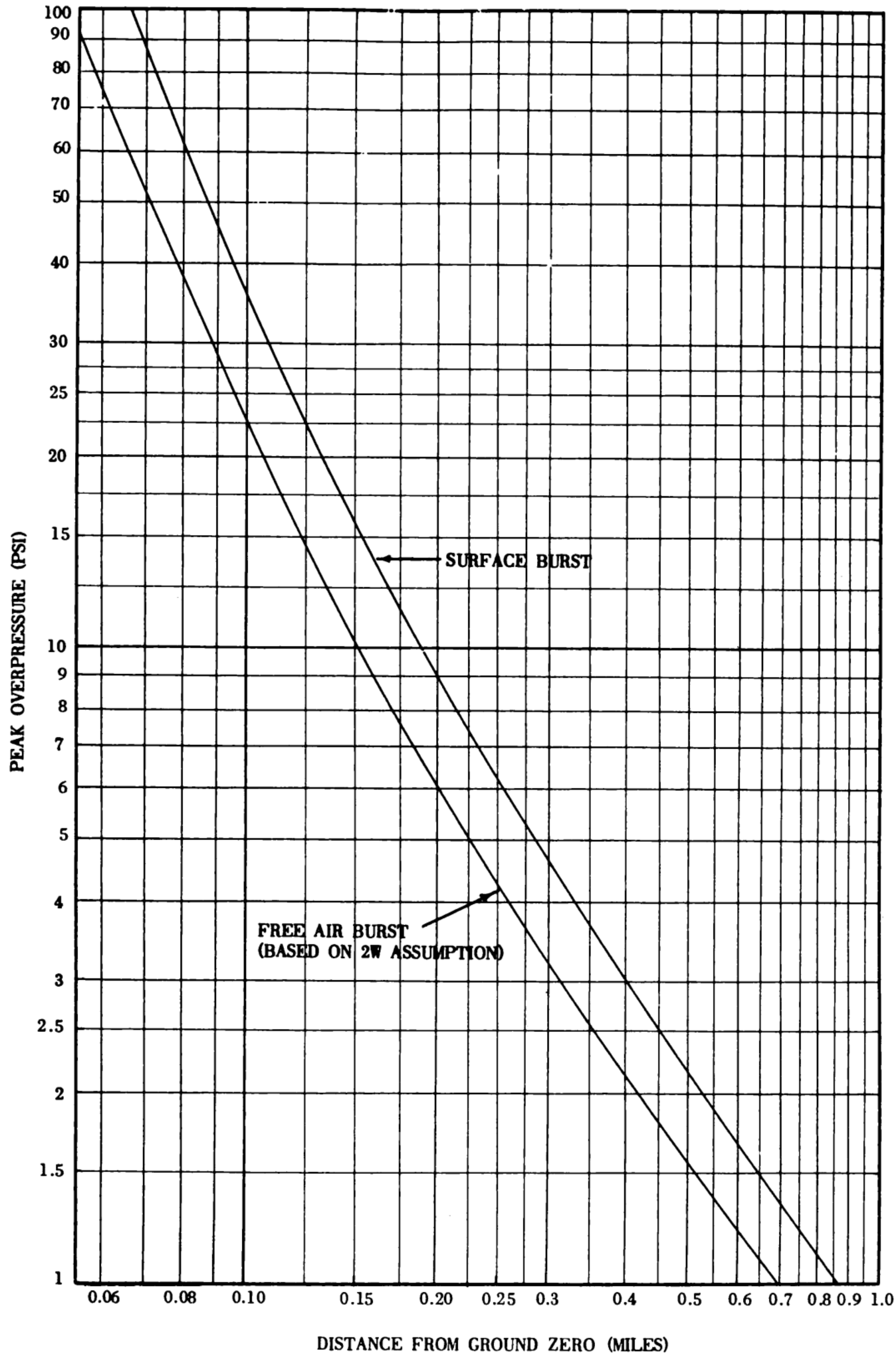


Figure 3.94a. Peak overpressure for a 1-kiloton surface burst and free air burst.

TABLE 6.12

DAMAGE CRITERIA FOR SHALLOW BURIED OR EARTH COVERED SURFACE STRUCTURES

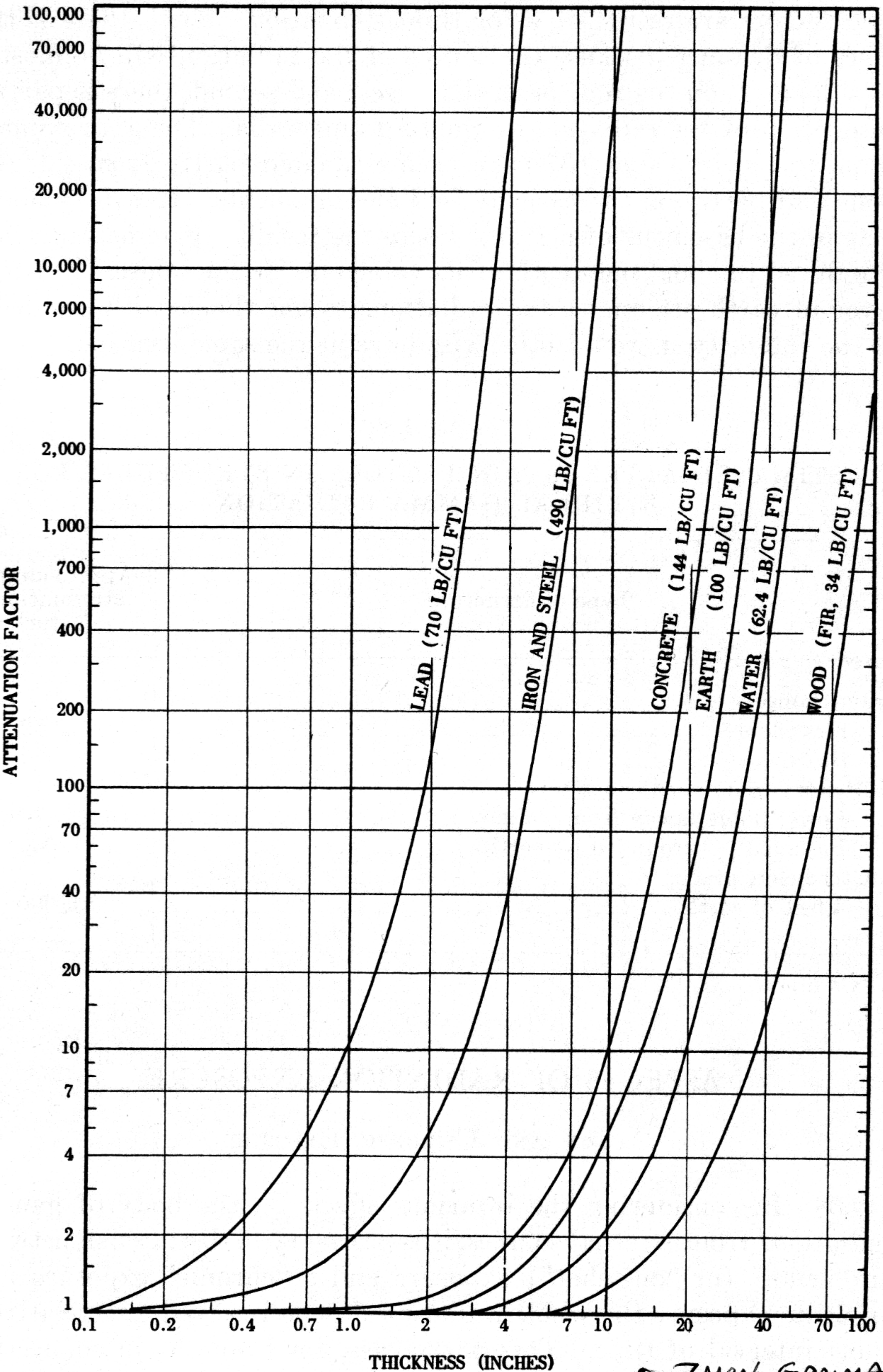
Type of structure	Damage class	Peak overpressure (psi)	Nature of damage
Light, corrugated steel arch, surface structure (10-gage corrugated steel with a span of 20 to 25 feet) with 3 feet of earth cover over the crown.	A	35–40	Complete collapse.
	B	30–35	Collapse of portion of arch facing blast.
	C	20–25	Deformation of end walls and arch, possible entrance door damage.
	D	10–15	Possible damage to ventilation system and entrance door.
Light, reinforced-concrete surface or underground shelter with 3 feet minimum earth cover. (Panels 2 to 3 inches thick, with beams spaced on 4-foot centers.)	A	30–35	Collapse.
	B	25–30	Partial collapse.
	C	15–25	Deformation, severe cracking and spalling of panels.
	D	10–15	Cracking of panels, possible entrance door damage.

6.13 An illustration of B-type damage to a 10-gage corrugated steel-arch, earth-covered, surface structure is shown in Fig. 6.13. It will be noted that about half of the arch has collapsed. This failure was attributed primarily to the dynamic pressure acting on the forward slope of the earth mound.

6.14 The peak overpressure for the complete collapse of the corrugated steel-arch structure, with 3 feet of earth cover, is given in Table 6.12 as 35 to 40 pounds per square inch. However, it has been estimated that if this structure had been completely buried, so that no earth mound was required, an overpressure of 40 to 50 pounds per square inch would have been necessary to cause it to collapse. This increase in the required overpressure is due to the fact that the dynamic pressure is minimized under these conditions. It may be mentioned

Figure 6.13. B-type damage to earth-covered 10-gage corrugated steel structure.

that, using standard engineering techniques, it is possible to design underground structures which will withstand blast overpressures in excess of 100 pounds per square inch at the surface (see Chapter XII).



0.7 MeV GAMMAS

Figure 9.36. Attenuation of fission product radiation. (FALLOUT)

9.42 An estimate of the total radiation dose, due to purely natural sources, received per annum by human beings, over the whole body, is given in Table 9.42. It is assumed that the underlying rock is granite, and data are given for sea level and an elevation of 5,000 feet. In some locations the background radiation dose from soil and rocks is less than from granite, but it appears that, in most parts of the United States, the natural radiation exposure dose is about 0.14 to 0.16 roentgen per year.

TABLE 9.42

ESTIMATED DOSE PER ANNUM FROM NATURAL BACKGROUND RADIATION

Radiation source	Roentgens per year	
	Sea level	5,000 feet altitude
Potassium in body	0. 020	0. 020
Thorium, uranium, and radium in granite	0. 055	0. 055
Potassium in granite	0. 035	0. 035
Cosmic rays	0. 035	0. 050
Total	0. 145	0. 16

9.43 It follows, therefore, that during the average lifetime every human being receives a total of 10 to 12 roentgens of nuclear radiation over the whole body from natural sources. In addition, there may be localized exposures associated with dental and chest X-rays, and similar treatments, and even from the luminous dials of wrist watches and instruments. The exposure to radiation from natural sources has undoubtedly continued during the whole period of man's existence.

TABLE 11.72

SUMMARY OF CLINICAL SYMPTOMS OF RADIATION SICKNESS

Time after exposure	Survival improbable (700 r or more)	Survival possible (550 r to 300 r)	Survival probable (250 r to 100 r)
	Nausea, vomiting, and diarrhea in first few hours.	Nausea, vomiting, and diarrhea in first few hours.	Possibly nausea, vomiting, and diarrhea on first day.
1st week	No definite symptoms in some cases (latent period).		
	Diarrhea Hemorrhage Purpura Inflammation of mouth and throat. Fever	No definite symptoms (latent period).	No definite symptoms (latent period).
2nd week	Rapid emaciation Death (Mortality probably 100 percent).	Epilation Loss of appetite and general malaise. Fever	
3rd week		Hemorrhage Purpura Petechiae Nosebleeds Pallor Inflammation of mouth and throat. Diarrhea Emaciation	Epilation Loss of appetite and malaise Sore throat Hemorrhage Purpura Petechiae Pallor Diarrhea Moderate emaciation.
4th week		Death in most serious cases. (Mortality 50 percent for 450 roentgens.)	Recovery likely in about 3 months unless complicated by poor previous health or superimposed injuries or infections.

Figure 12.40a. Earth-moving equipment subjected to nuclear blast in open terrain (30 psi overpressure). **Teapot-MET, 1955**

Figure 12.40b. Earth-moving equipment subjected to nuclear blast in open terrain (30 psi overpressure). **Teapot-MET, 1955**

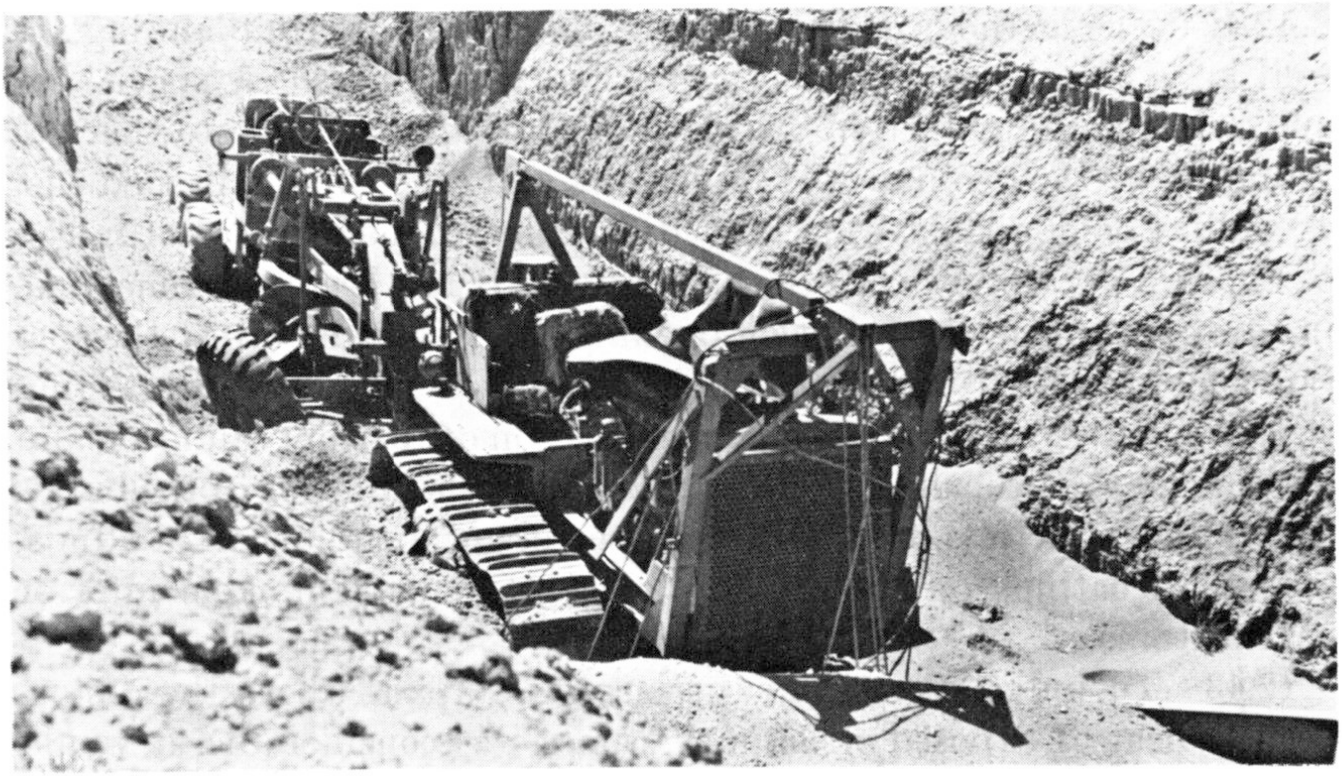


Figure 12.40c. Earth-moving equipment protected in deep trench at right angles to blast wave motion (30 psi overpressure).

Teapot-MET, 1955

12.40 The destruction caused by a nuclear explosion to two pieces of earth-moving equipment, which are largely drag-sensitive, is shown in Figs. 12.40a and b. Two similar pieces of equipment located in a deep trench, at the same distance from the explosion, are seen in Fig. 12.40c to have been essentially unharmed. It is important to mention that the main direction of the trench was at right angles to the motion of the blast wave. If the wave had been traveling in the same direction as the trench, the equipment would probably have been severely damaged. Consequently, in order to provide protection from drag forces, the orientation of the trench or earth revetment, with respect to the expected direction of the explosion, is of great importance.

Fire Protection

12.41 It was noted in Chapter VII that fires following a nuclear explosion may be started by thermal radiation and by secondary effects, such as overturning stoves and furnaces, rupture of gas pipes, and electrical short circuits. Fire-resistive construction and avoidance of fabrics and other light materials of inflammable character are essential in reducing fire damage. As shown by the tests described in § 7.82, a well-maintained house, with a yard free from inflammable rubbish, was less easily ignited by thermal radiation than a house that has not had adequate care.

12.60 In the event of a surprise attack, when there is no opportunity to take shelter, immediate action could mean the difference between life and death. The first indication of an unexpected nuclear explosion would be a sudden increase of the general illumination. It would then be imperative to avoid the instinctive tendency to look at the source of light, but rather to do everything possible to cover all exposed parts of the body. A person inside a building should immediately fall prone and crawl behind or beneath a table or desk. This will provide a partial shield against splintered glass and other flying missiles. No attempt should be made to get up until the blast wave has passed, as indicated possibly by the breaking of glass, cracking of plaster, and other signs of destruction. The sound of the explosion also signifies the arrival of the blast wave.

12.61 A person caught in the open by the sudden brightness due to a nuclear explosion, should drop to the ground while curling up to shade the bare arms, hands, neck, and face with the clothed body. Although this action may have little effect against gamma rays and neutrons, it might possibly help in reducing flash burns due to thermal radiation. The degree of protection provided will vary with the energy yield of the explosion. As stated in § 7.53, it is only with high-yield weapons that evasive action against thermal radiation is likely to be feasible. Nevertheless, there is nothing to be lost, and perhaps much to be gained, by taking such action. The curled-up position should be held until the blast wave has passed.

12.62 If shelter of some kind, no matter how minor, e. g., in a doorway, behind a tree, or in a ditch, or trench can be reached within a second, it might be possible to avoid a significant part of the initial nuclear radiation, as well as the thermal radiation. But shielding from nuclear radiation requires a considerable thickness of material and this may not be available in the open. By dropping to the ground, some advantage may be secured from the shielding provided by the terrain and surrounding objects. However, since the nuclear radiation continues to reach the earth from the atomic cloud as it rises, the protection will be only partial. Further, as a result of scattering, the radiations will come from all directions.

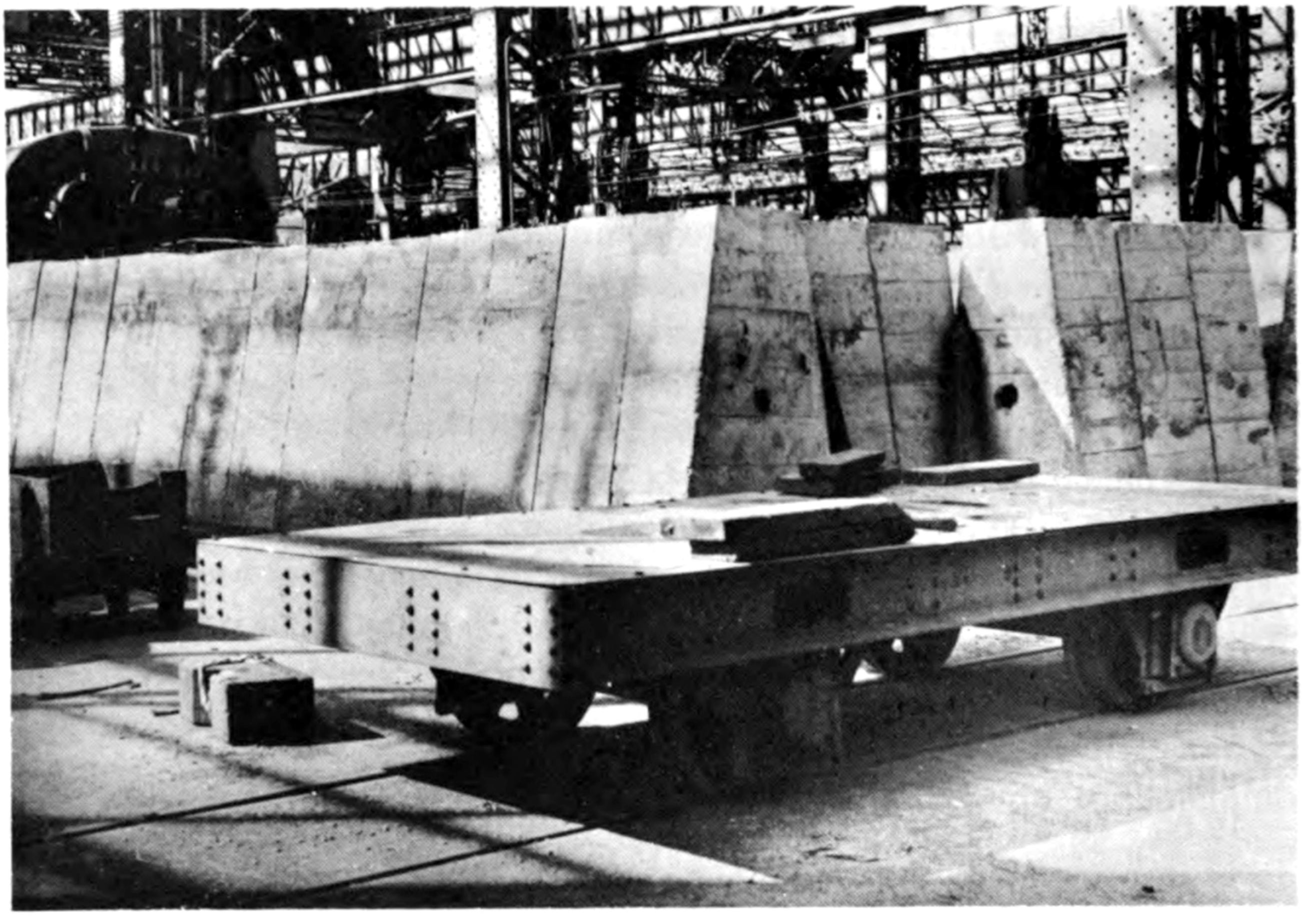


Figure 12.37a. Precast, reinforced-concrete blast walls (0.85 mile from ground zero at Nagasaki).

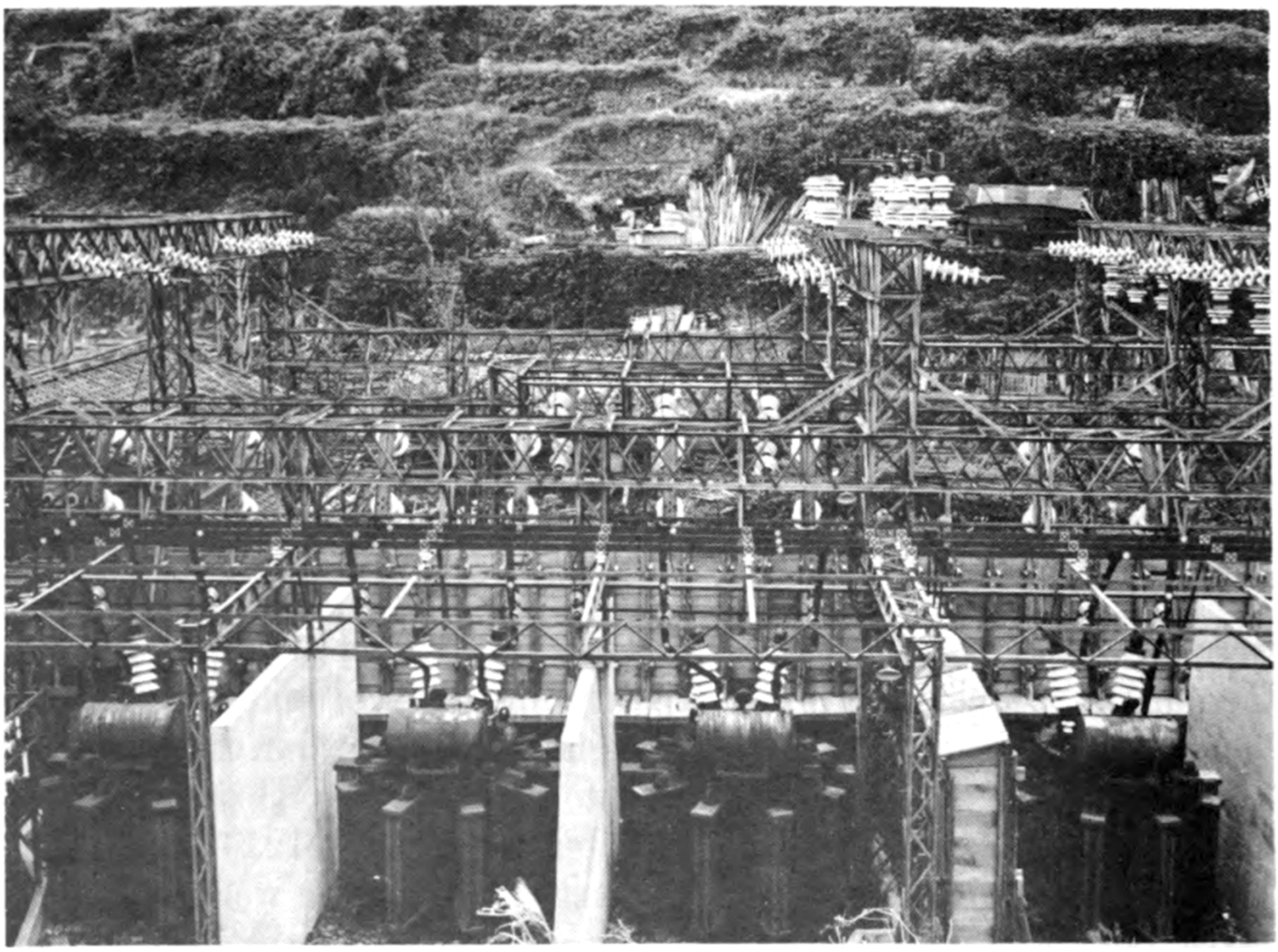


Figure 12.37b. Reinforced-concrete blast walls protecting transformers (1 mile from ground zero at Nagasaki).

WHEN YOU GO TO SHELTER

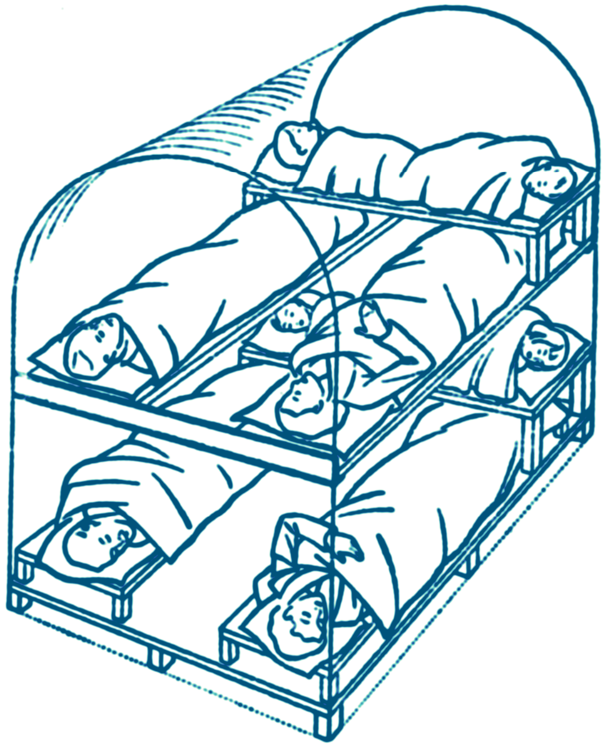
Your Anderson shelter this Winter

1940

ISSUED BY THE MINISTRY OF HOME SECURITY

BY FAR THE BEST bedding for any shelter is a properly made sleeping bag. Nothing else can give so much warmth.

Take any Army or similar thick blanket about 7 ft. long and 6½ ft. wide (or pieces of old blankets could, of course, be joined together). Line with muslin or cotton material to within a short distance of the top. Sew straight across both blanket and lining horizontally at intervals of about a foot, making pockets which should be well stuffed with folded newspaper. The newspaper stuffing should be changed every month.



HOW TO MAKE BUNKS

Look at the diagram of the arrangement of bunks and you will at once see the idea. The top bunks run from one end of the shelter to the other, the ends resting on the angle-irons that run horizontally across the shelter at each end. These bunks should be 20 in. wide, and about 6 ft. 6 in. long.

The cross bunks for the children are 4 ft. 6 in. long, and have four legs, each 14 in. high, which rest on the side pieces of the lengthways bunks.

SECRET.

W.P.(G)(41)7. COPY NO. 62

January 15th, 1941.

WAR CABINET.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

---

6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

(i) that proposals for building shelters of massive construction should be rejected;

(ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;

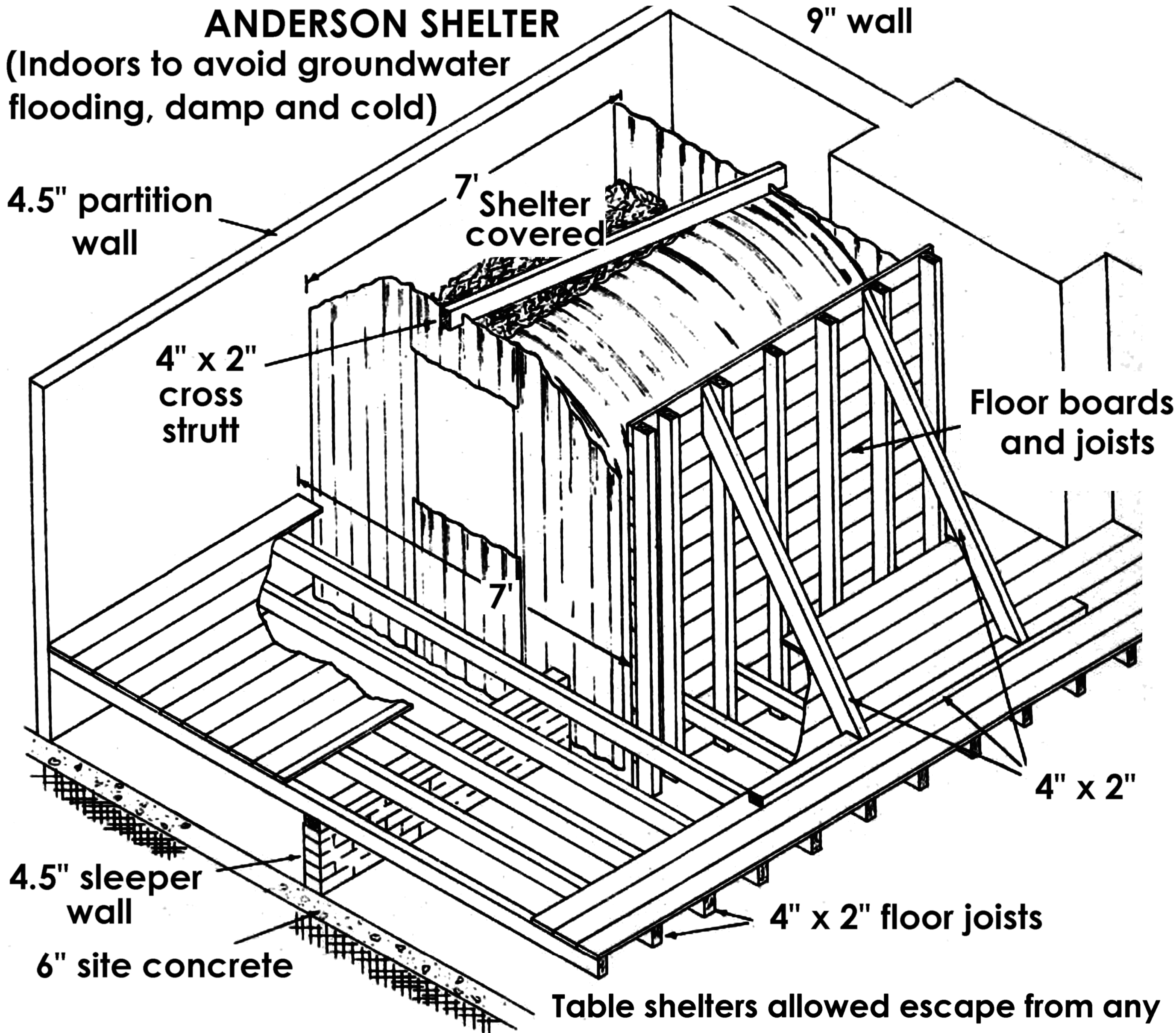
(iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

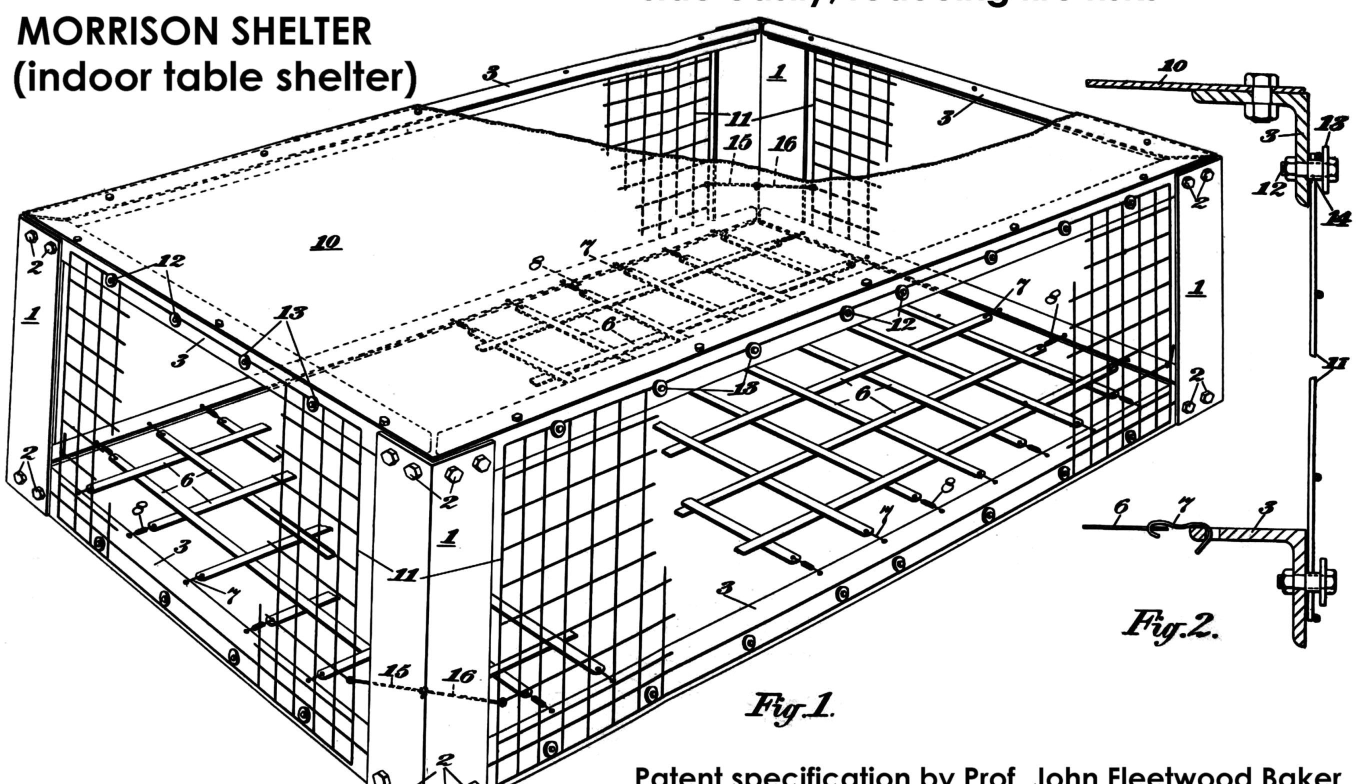
H.M.

MINISTRY OF HOME SECURITY.

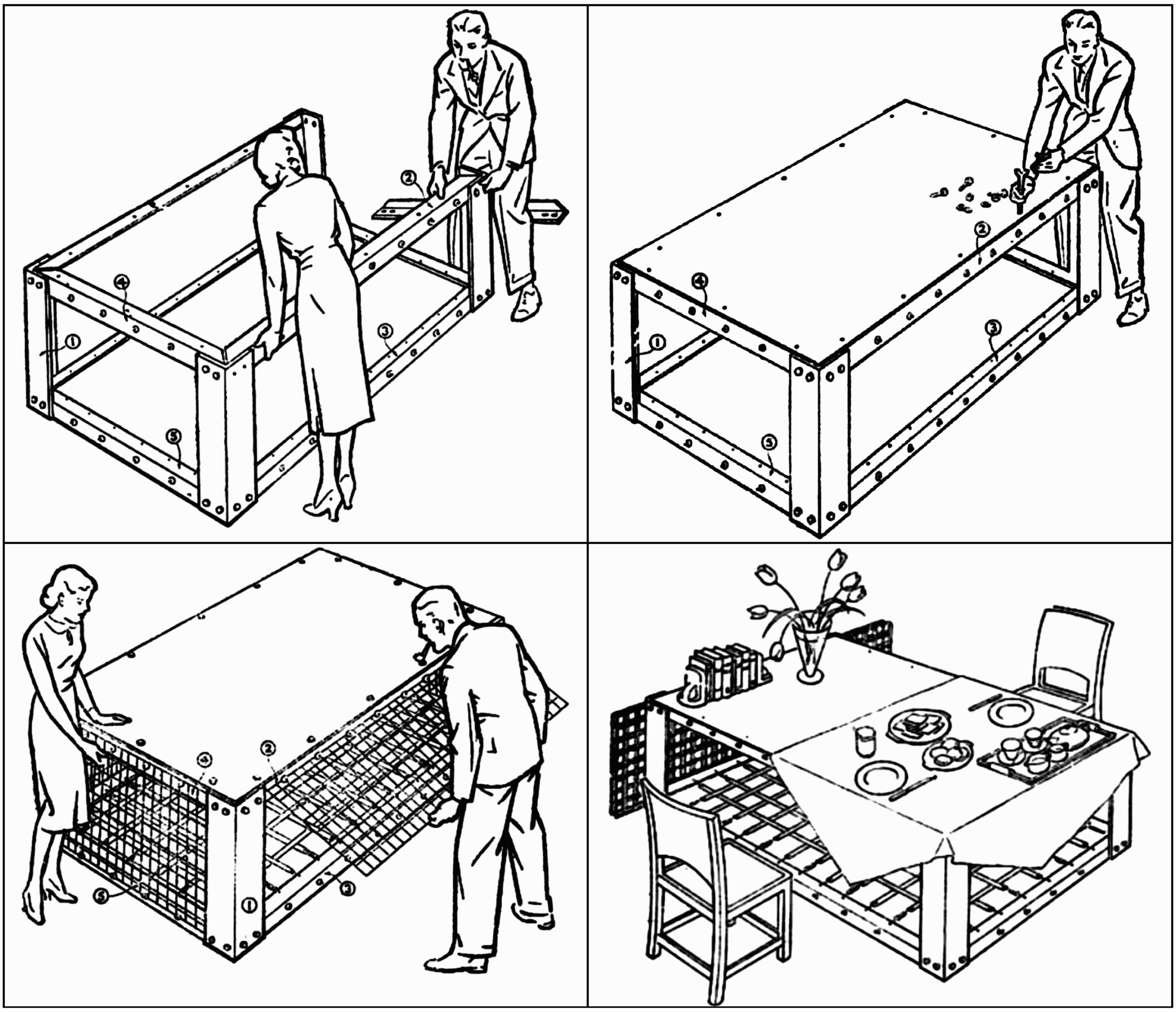
January 15th, 1941.

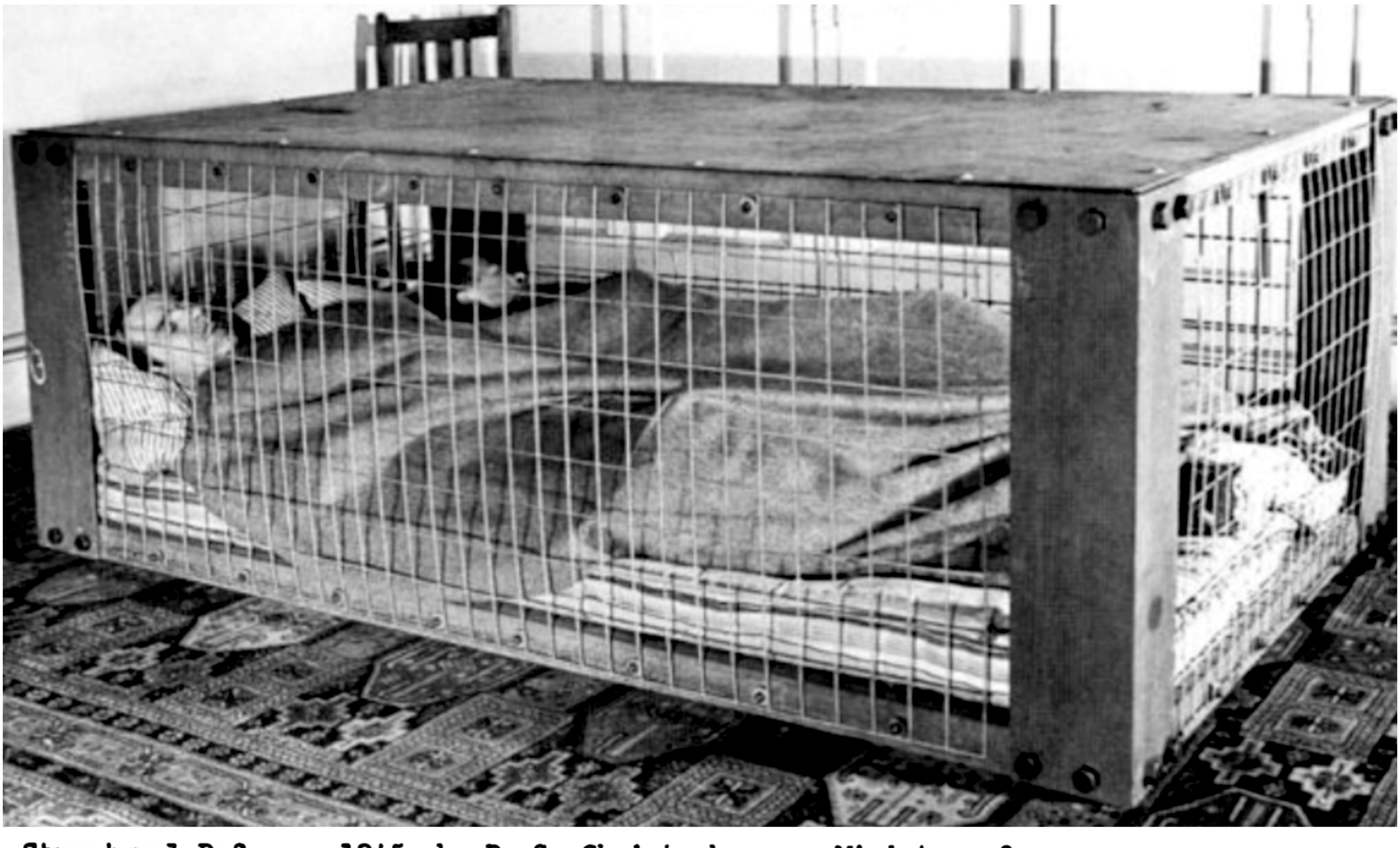
November 1940 design by C. A. Joy, M. Inst. Me. & C. E., Bexley Borough Engineer (UK National Archives: HO 205/257)





Patent specification by Prof. John Fleetwood Baker, Ministry of Home Security (National Archives HO 356/10)





Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential). Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness.

National Archives
HO 195/16

SHELTER at home

3d. ISSUED BY THE MINISTRY OF HOME SECURITY AND PUBLISHED BY H.M. STATIONERY OFFICE

ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.

(Page 11 from the June 1941 UK Ministry of Home Security "Shelter at Home" handbook.)





Morrison shelter survives direct hit in York 1942

Morrison Shelters in Recent Air Raids.

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrisons" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.

Issued for the Ministry of Home Security
by the Ministry of Information

FRONT LINE

1940-41

The Official Story of the
CIVIL DEFENCE
of Britain

1942
London: His Majesty's Stationery Office

THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

THE NEW LIFE BECOMES ORGANISED. Food, medical services, entertainments were provided—an all night canteen in a Tube tunnel, one of London's biggest shelters.

THE NIGHTLY MIRACLE. Another kind of shelter life was led in something like a million back-garden Andersons. Four people and a dog were trapped in this one when a bomb blew a crater alongside. All came out alive.

So far was all this from panic that it took three months for the population of the twenty-eight central boroughs to drop by about 25 per cent. from a little over 3,000,000 (the figure before heavy bombing began) to 2,280,000 at the end of November. In a group of the most heavily bombed eastern boroughs the pre-war population of 800,000 had fallen to 582,000 before the blitz began; for four months it had dropped steadily to 444,000; by 31st December a fall of 23 per cent. These figures do not spell panic, and a further substantial fall in 1941, after continuous heavy raiding had ceased, completes the evidence that those who went did so in cold blood, for practical reasons as valid for their hard-pressed city as for their private selves.

But what did all this mean to the average Londoner? In November, inner London (the county) contained some 3,200,000 people. Not more than 300,000 of these were in public shelter of any kind, half of that number at most in those larger shelters on which the limelight shone so exclusively. Nor is this all; in domestic shelter (Andersons, small brick shelters and private reinforced basements) there were no more than

1,150,000 people. Thus of every hundred Londoners living in the central urban areas, nine were in public shelter (of whom possibly four were in "big" shelters), 27 in private shelter, and 64 in their own beds—possibly moved to the ground floor—or else on duty. Particular big shelters, and for a few nights the tubes, were overcrowded, but there was public shelter for twice the number who made use of it. In outer London, with a population of some 4,600,000, there were in November 4 per cent. in public shelter, 26 per cent. in domestic shelter, and 70 per cent. at home or on duty.

In the last great war there had been outbursts of hate against the distant enemy, and shops with German names had been wrecked. This time the citizens did not stop for such things. After the first shock of realisation they found no more need for direct recrimination than does the soldier. Like him, they got on with the job and waited their chance. Neither in this nor in any other way was there a sign of instability; no panic running for shelter, no white faces in the streets (though plenty of taut, grim ones), no nerve disease. In all London, the month of October saw but twenty-three neurotics admitted to hospital. The mind-doctors had rather fewer patients than usual.

Balham High Road, London, 15 October 1940

BLOCKED ROADS. The morning of 12th May: each raid sets the police still another traffic problem.

ENORMOUS CRATERS. At the Bank, where the road collapsed into the subway beneath. A temporary bridge was thrown right across it.


CITY OF COVENTRY
PREVENTION OF TYPHOID FEVER
In view of present damage to DRAINAGE communications in the City, special precautions against Typhoid Fever are advised:
BOIL ALL DRINKING WATER

LIVERPOOL : Lord Street ; South Castle Street ; Customs House in the background.

The outcome may be seen in the following table, which shows coastal bombing to November, 1941, in round figures.

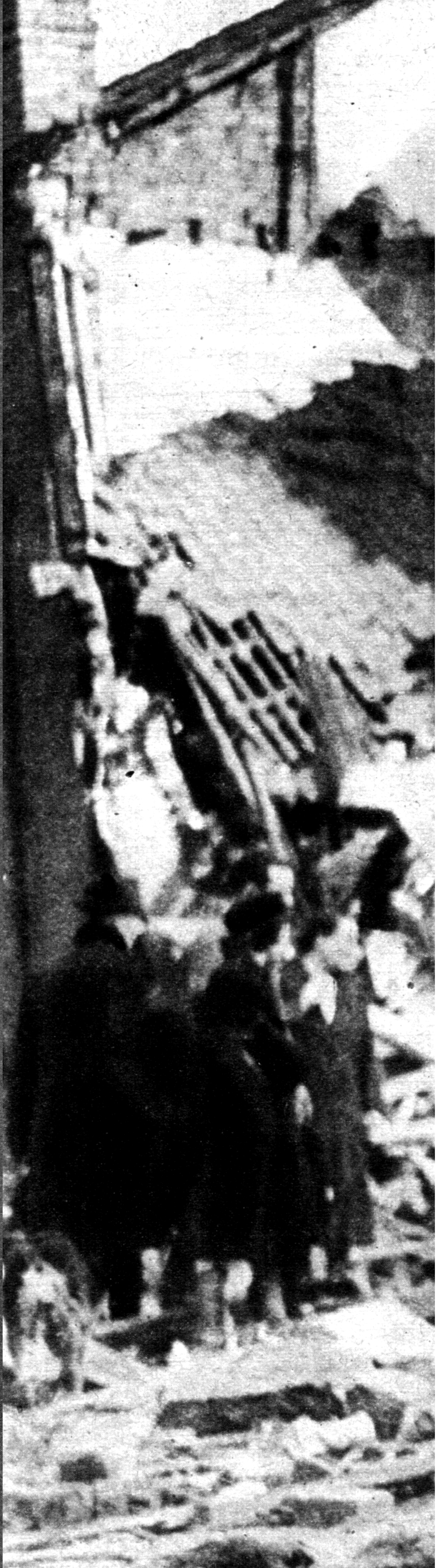
Town.	*Number of Raids.*	*Civilians Killed.*	*Houses Damaged.*
Fraserburgh ...	18	40	700
Peterhead ...	16	36	700
Aberdeen ...	24	68	2,000
Scarborough ...	17	30	2,250
Bridlington ...	30	24	3,000
Grimsby	22	18	1,700
Gt. Yarmouth ...	72	110	11,500
Lowestoft ...	54	94	9,000
Clacton	31	10	4,400
Margate ...	47	19	8,000
Ramsgate ...	41	71	8,500
Deal	17	12	2,000
Dover	53 (and shelling)	92	9,000
Folkestone ...	42	52	7,000
Hastings	40	46	6,250
Bexhill	37	74	2,600
Eastbourne ...	49	36	3,700
Brighton / Hove ...	25	127	4,500
Worthing ...	29	20	3,000
Bournemouth ...	33	77	4,000
Weymouth ...	42	48	3,600
Falmouth ...	33	31	1,100

NORTH-EAST HERO. In one of the countless tip-and-run raids with which the Luftwaffe harried Britain's coastline this 14-year-old schoolboy worked all through the night rescuing buried people.

"I see the damage done
by the enemy attacks;
but I also see,
side by side with
the devastation
and amid the ruins,
quiet, confident, bright
and smiling eyes,
beaming with a consciousness
of being associated
with a cause
far higher and wider
than any human
or personal issue.
I see the spirit
of an unconquerable people"

WINSTON CHURCHILL

April 12th, 1941



Aldwych, 30 June 1944, V1 attack

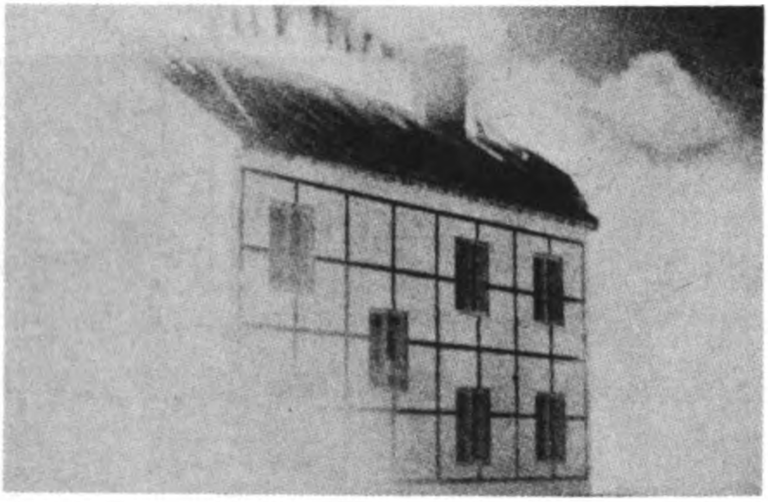
UK NATIONAL ARCHIVES: HO225/16 (1950)

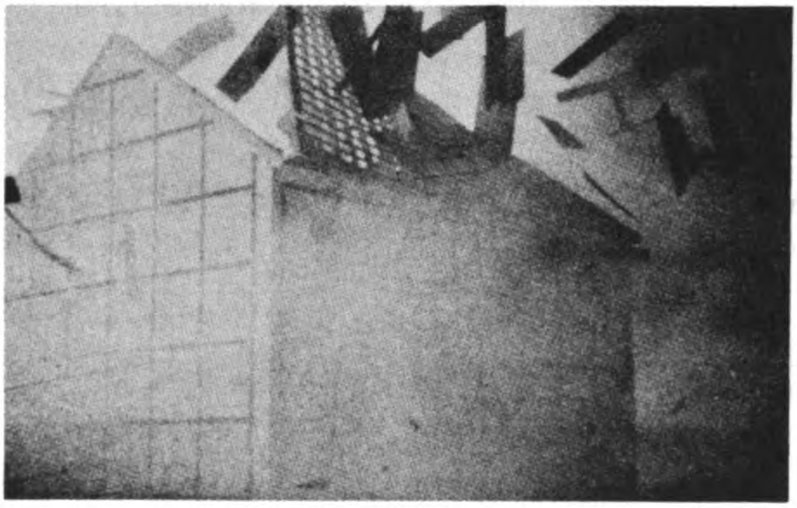
THE NUMBER OF ATOMIC BOMBS EQUIVALENT TO THE LAST WAR AIR ATTACKS ON GREAT BRITAIN AND GERMANY

Summary

During the last war, a total of 1,300,000 tons* of bombs were dropped on Germany by the Strategic Air Forces. If there were no increase in aimi[ng] accuracy, then to achieve the same total amount of material damage (to houses, industrial and transportation targets, etc.) would have required the use of over 300 atomic bombs together with some 500,000 tons of high explosive and incendiary bombs for targets too small to warrant the use of an atomic bomb. Increases in accuracy could cause a substantial reduction in this figure of 300 atomic bombs, to as few as 100-150 bombs for very accurate attacks.

47 kt Greenhouse Easy, Eniwetok Atoll, 1951. Brick house, 3 psi peak overpressure





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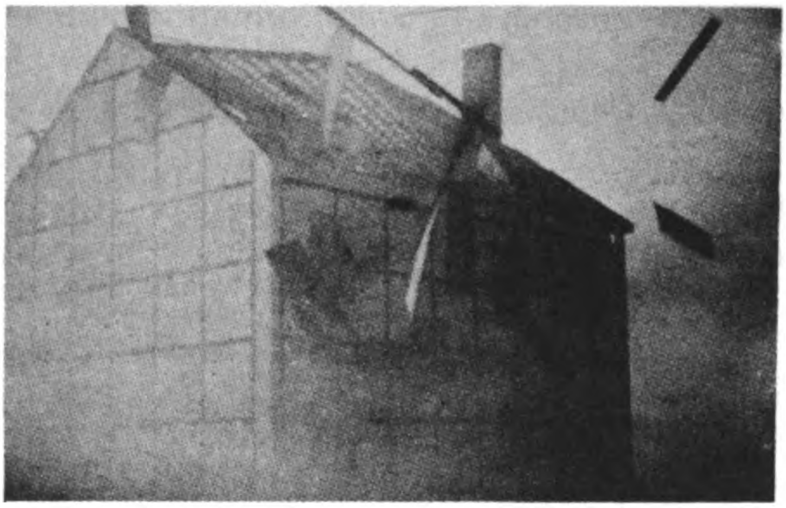

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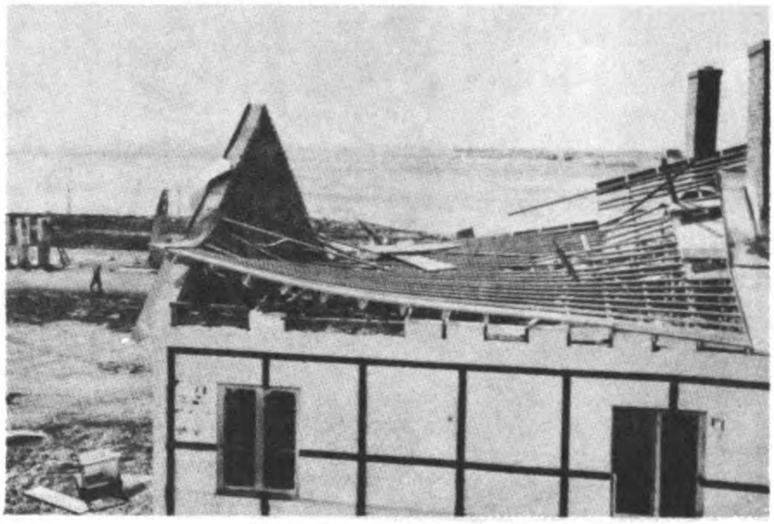


Afterward

CIVIL DEFENCE

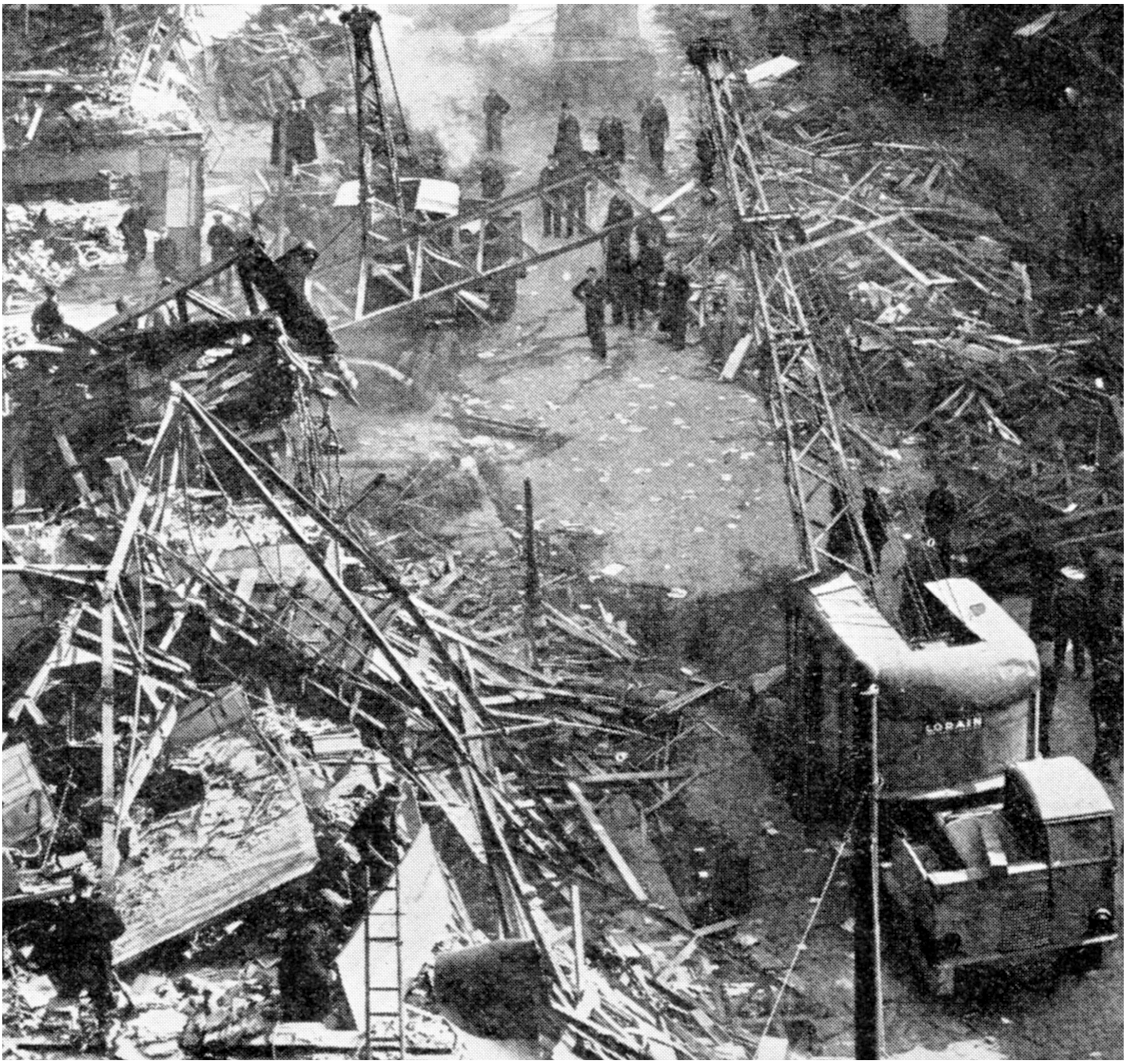
RESCUE MANUAL

LONDON
HER MAJESTY'S STATIONERY OFFICE
1952

CHAPTER XI. USE OF HEAVY MECHANICAL PLANT IN RESCUE, DEMOLITION AND CLEARANCE OPERATIONS

In the last war it was found that at major incidents the use of heavy mechanical plant was frequently necessary in support of rescue operations. Such equipment was used to help in the quick removal of debris; to lift heavy blocks of brickwork or masonry; to take the weight of collapsed floors and girders so that voids could be explored and casualties extricated; to haul off twisted steelwork and other debris and to break up sections of reinforced concrete.

In future all these tasks may be required and heavy clearance may have to be effected to enable rescue and other Civil Defence vehicles



8 March 1945 Fig. 20 **1 ton of TNT equivalent**

Using heavy mechanical plant at the Smithfield Market V.2 incident.

to approach within measurable distance of their tasks. The problem of debris will in fact be a major factor in Civil Defence operations.

Heavy mechanical plant may be required for the following purposes :

(*a*) To assist in the removal of persons injured or trapped. At this stage mainly heavy plant is needed, particularly mobile cranes with sufficient length of boom or jib to reach for long distances over the wreckage of buildings.

(*b*) To force a passage for Civil Defence vehicles and fire appliances to enable them to reach areas where major rescue and other problems exist and require urgent operational action.

(*c*) To take certain safety measures—e.g., to pull down unsafe structures.

(*d*) To clear streets and pavements to help restore communications and to afford access for the repair of damaged mains and pipes beneath the streets.

(*e*) For the final clearance of debris and the tidying of sites. This is a long term and not an operational requirement.

Urgent Rescue Operations

During rescue operations in London in the last war the machines used with great success included heavy 3½-5 ton mobile cranes, mounted on road wheels, with a 30-40 ft. jib ; medium heavy 2-3½ ton mobile cranes, mounted on road wheels, with a 26 ft. jib ; heavy crawler tractor bulldozers ; medium crawler tractor bulldozers ; mechanical shovels and compressors, three stage, mounted on road wheels.

In the case of a large or multiple incident where access was obstructed by considerable quantities of scattered debris, a bulldozer or tractor was first employed in order to clear one or more approaches by which other equipment and personnel could reach the scene of operations.

Next, all debris of manhandling size was loaded into one-yard skips and discharged by the crane into lorries, giving increased manœuvring space to the Services operating on the site.

Heavy mobile cranes were then brought up to the incident where, used under the skilled direction of the rescue party Leader, they were invaluable for removing girders and large blocks of masonry which obstructed access to casualties or persons trapped. The necessary chains and wire ropes for these operations formed part of the standard equipment of the heavy and medium-heavy mobile cranes.

The work was, of course, carried out in close co-operation with the Rescue Parties who also used various forms of light mechanical equipment, such as jacks and ratchet lifting tackle for work in confined spaces.

Compressors sometimes proved valuable for breaking up large masonry such as fallen walls, into sections of a size and weight within the handling and lifting capacity of the cranes. This method was only used when it was known that there were no casualties under the masonry.

HOME OFFICE

SCOTTISH HOME DEPARTMENT

CIVIL DEFENCE HANDBOOK No. 7

Rescue

This Handbook is a revised edition of,
and replaces, the
Civil Defence Rescue Manual

LONDON

HER MAJESTY'S STATIONERY OFFICE

1960

CHAPTER 6

Types of Damage from Modern Air Attack

General Characteristics

6.1 When a nuclear weapon explodes an immense amount of energy is released almost instantaneously and the contents are transformed into a rapidly expanding white hot ball of gas at a temperature as high as that on the sun. From this "fireball" a pulse of intense light and heat is radiated in all directions. The materials in the fireball are also a source of radioactivity in various forms. As the fireball expands and cools, a powerful blast wave develops. As it cools still further, it shoots upwards to a height of many thousands of feet, billowing out at the top to give the appearance of a huge mushroom or cauliflower on its stalk.

6.2 The three forms of energy released in the explosion, namely, light and heat, radioactivity, and blast, all produce effects in different ways and in different proportions according to the position of the explosion in relation to the surface underneath. This chapter, however, deals primarily with the damage caused to buildings by the blast effect.

6.3 With nuclear weapons (as opposed to high explosive weapons), blast pressure rather than "impulse" tends to be the criterion of damage. If the effective blast pressure exceeds the static strength of the structure, failure must be expected. If it is less, no failure can occur however long the duration of the blast. In fact, nuclear bomb blast is more like a strong wind than the sudden blow of high explosive blast, and many of the failures observed at Hiroshima and Nagasaki and in subsequent tests resemble closely the kind of damage that might be done to buildings by a hurricane.

6.4 The scarcity of suction damage from the nominal bombs in Japan was due to the high blast pressures produced and to the fact that these were three or four times as great as the blast suction. With all such large explosions, if a building does not fail from blast pressure it is unlikely to fail under the lower stresses in the suction phase.

Effect of blast on structures

6.5 The type of damage which long duration blast (from nuclear weapons) causes to structures can possibly best be appreciated by considering the forces to which a simple building is subjected during the passage of a horizontal blast wave. When the blast "front" strikes the front wall it is reflected back, and the pressure in the wave front builds up to more than double the original pressure. However, this build-up only lasts for a very short time and is mainly important for large flat surfaces such as walls of big buildings.

Fig. 39 (a). Using a door as a stretcher

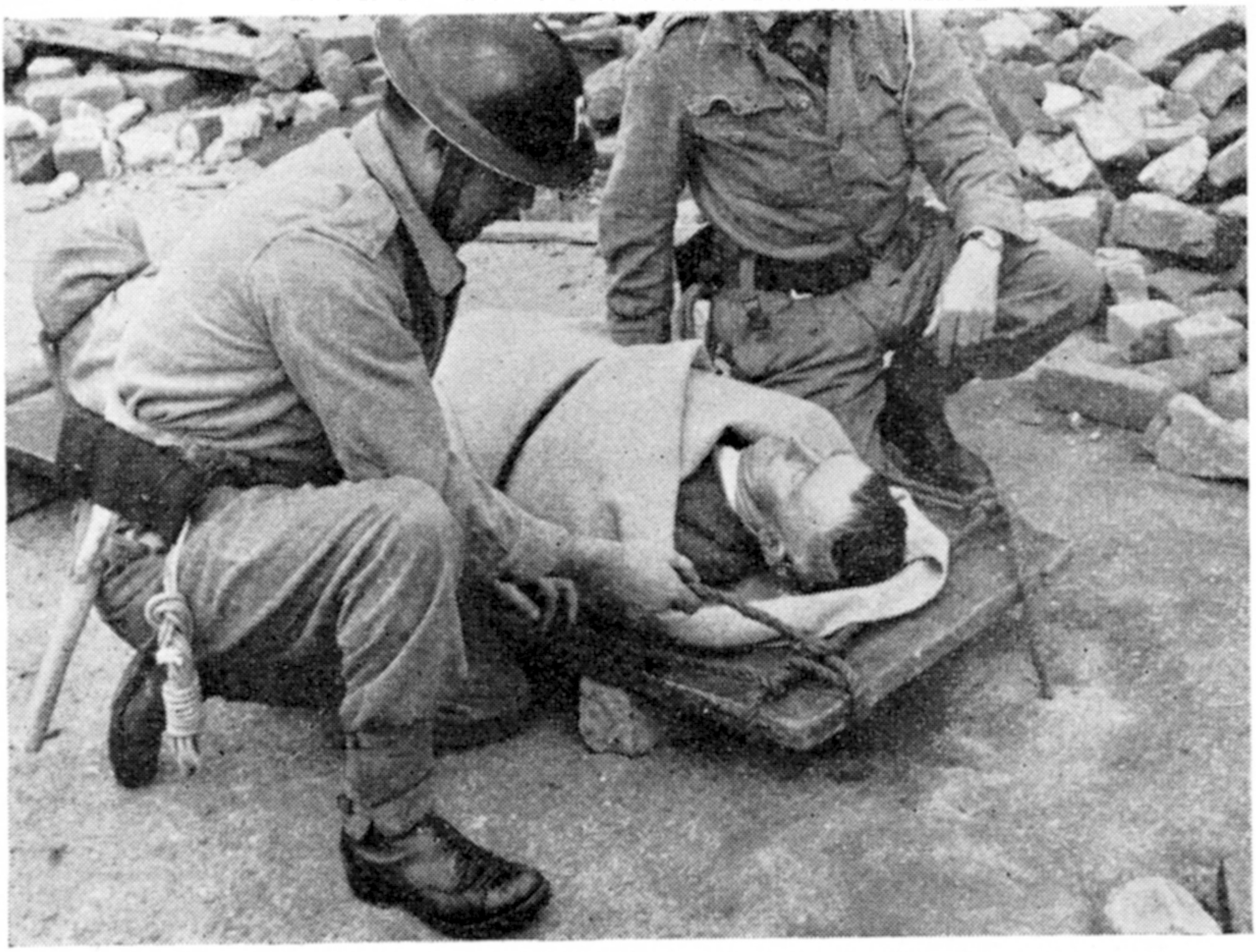


Fig. 39 (b). Using a door as a stretcher

CHAPTER 15

Principles of Levering and Jacking

15.1 The principles of levering and jacking are, in a variety of differing ways, brought into most aspects of rescue work. The purpose of lifting appliances is to gain power so as to lift a large load with a small force suitably applied.

Levers

15.2 The simplest appliance for gaining power is the lever, of which an improvised version made of laminated timber or an ordinary crowbar are most frequently used by rescue workers. There are two principal ways in which a lever can be used, as illustrated in the diagrams. In each case the advantage gained depends on the distance of (A), the centre of the load, and (C) the points where the push or force is applied from (B), the heel or fulcrum.

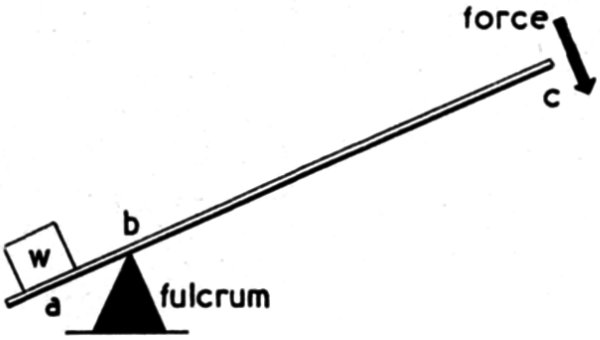
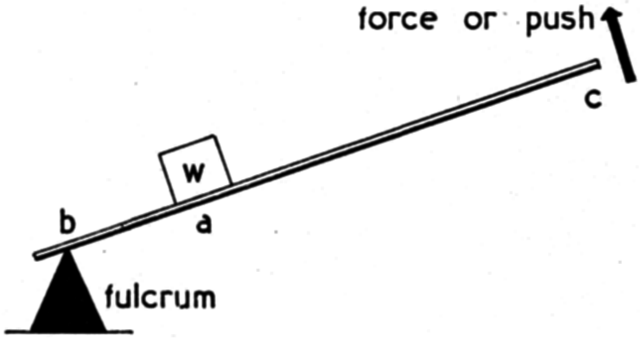


Fig. 68. Lever (downward force)



Lever (upward force)

15.3 The relation between the load and the amount of force required to lift it is in the same ratio as the length BC is to AB, where AB and BC are the distances of the weight and the force respectively from the fulcrum. A man using a 10-foot lever and bearing down at C with half his weight, say, 6 stone or 84 lb., against a fulcrum 1 foot from the other end of the lever, can lift a weight of $84 \times 9 = 756$ lb. because the length from fulcrum to hand is nine times the length from pivot to weight. If B is only 6 inches away from the weight the ratio is increased to 19 times its own weight.

Fulcrum blocks

15.4 A fulcrum block should be of wood (hardwood if possible), never of brick or other crushable material. It must be resting on a firm base, which should be as large as possible so as to distribute the weight to be lifted. The fulcrum must be placed as near to the weight as is possible under the circumstances, and it should never be placed at any point where there is a possibility of a casualty being buried immediately below.

In 12 months, 1940-1, the Blitz stray dog Rip (discovered by civil defence rescuers in Poplar, East London after an air raid) sniffed out 100 trapped casualties in London rubble.

Irma. Margaret Griffin used Irma and Psyche to find 233 trapped persons


join AR
enrol
at any
fire station
AFS

Amended Reprint
June, 1940

AIR RAID PRECAUTIONS
HANDBOOK No. 9

(*1st edition*)

INCENDIARY BOMBS AND FIRE PRECAUTIONS

Issued by the
Ministry of Home Security

LONDON
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

FIG. 1—TYPICAL KILO MAGNESIUM INCENDIARY BOMB.

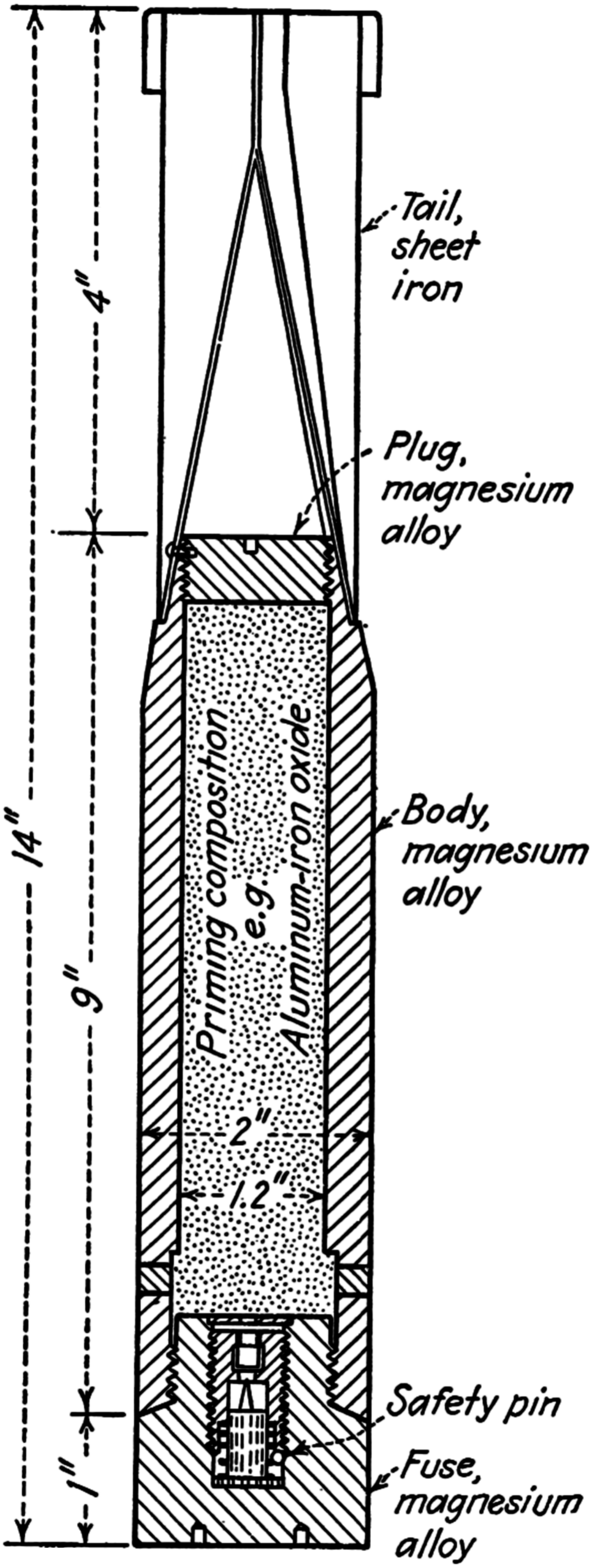


FIG. 2—TYPICAL KILO MAGNESIUM INCENDIARY BOMB. SECTIONAL DRAWING.

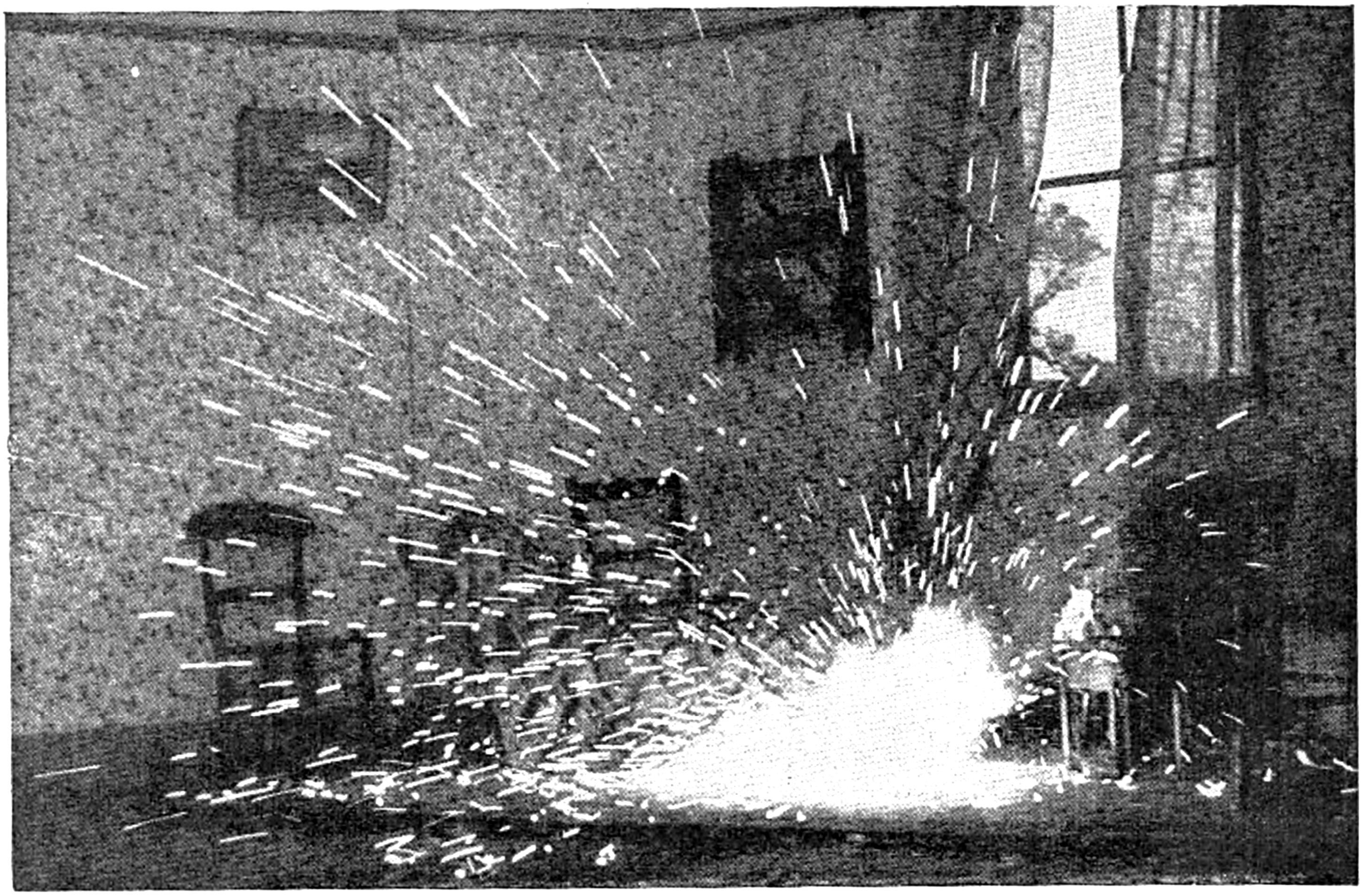


FIG. 4—KILO MAGNESIUM INCENDIARY BOMB 15 SECONDS AFTER IGNITION.

FIG. 5—FIRE CAUSED BY KILO MAGNESIUM INCENDIARY BOMB 45 SECONDS AFTER IGNITION.

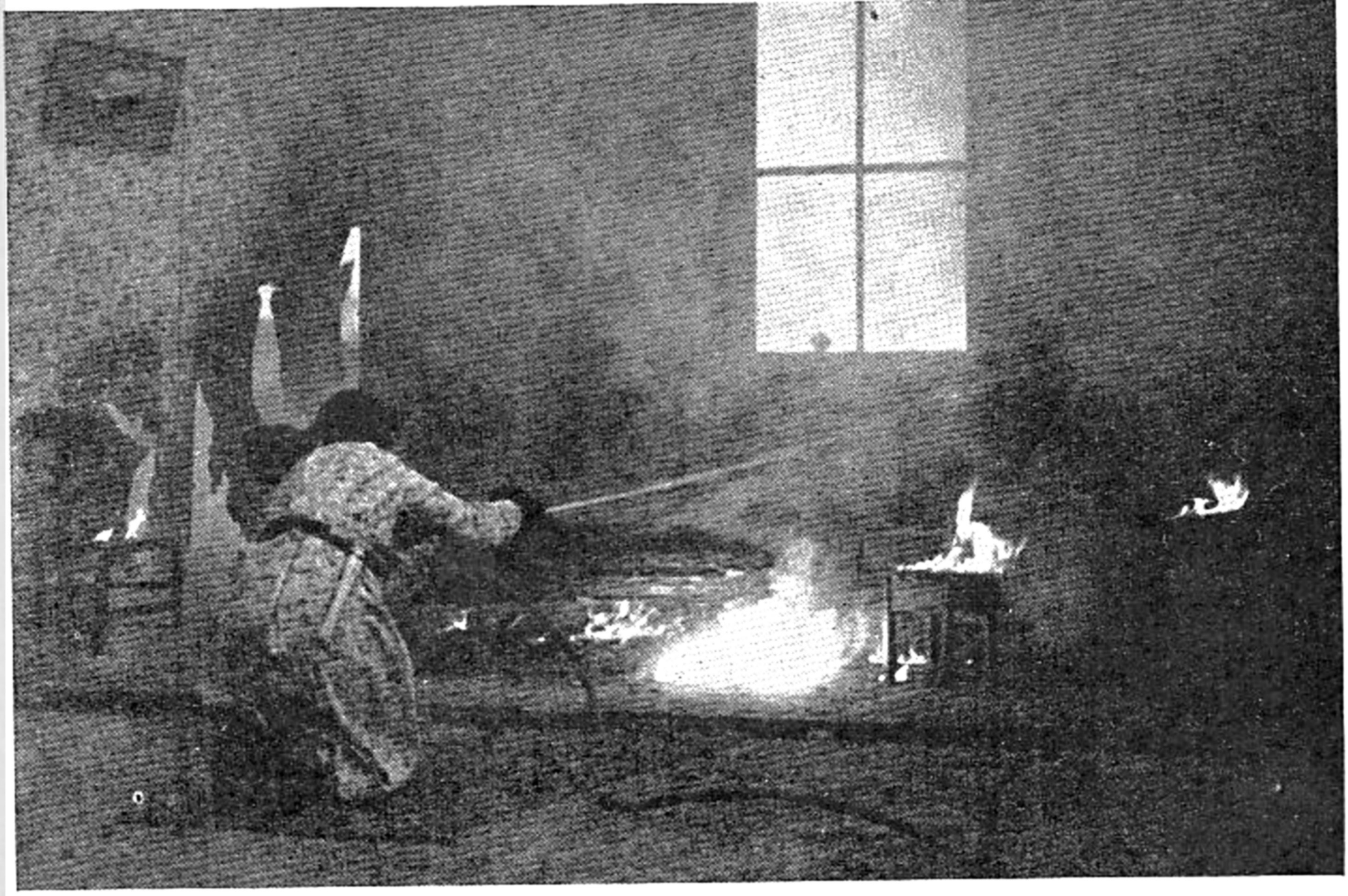


FIG. 6—FIRE CONTROLLED BY WATER USING JET FROM STIRRUP HAND-PUMP.

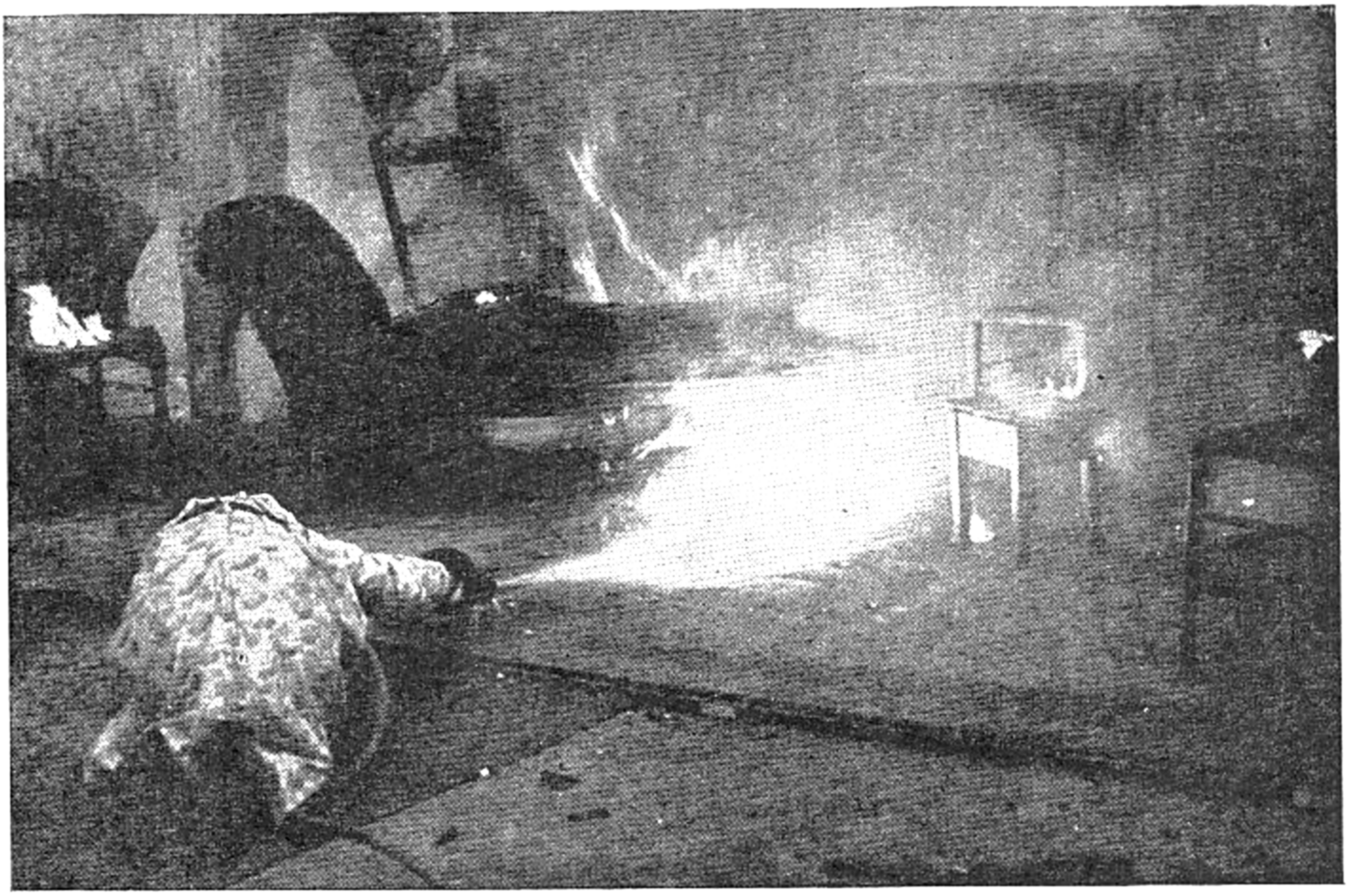


FIG. 7—WATER APPLIED TO BURNING BOMB USING SPRAY FROM STIRRUP HAND-PUMP.

Clothing on fire.

Never allow a person whose clothes are on fire to remain standing for a moment. Fatalities nearly always arise from shock of burning about the face and head. If the person starts to run, trip him up at once. Roll him on the floor or in a coat or blanket if you have one handy. If your own clothes catch fire, clap your hand over your mouth, and lie down and roll.

Escaping through a window.

If you have to escape from a room by the window without the aid of a rope, or even of sheets joined together, do not jump. Sit on the window-sill with your legs outside, turn over, and slide out till you have a finger grip on the edge of the window-sill and then let go. The drop will be reduced by the length of your reach and body (Figs. 15, 16, and 17).

To lower a person from a window.

Place the rope under the shod instep and three points of friction will be obtained, which will make the lowering of the heaviest person relatively easy (Fig. 18). For practice purposes, a dummy or a weight should be used.

Note.—Escape from a window should only be attempted as a last resource.

Extinguishing a fire.

Quite a small pumping appliance, such as the stirrup hand-pump, should extinguish a fire in any one room if used with promptitude, pluck, and intelligence. But you will do little good unless you can attack the heart of the fire from fairly close range, say, at most 25 ft.

When a fire is inside a room keep the door closed till appliances are in position and ready to operate, and never open up a floor or cut away any woodwork to get at a fire till you are ready to attack it.

Do not overlook the possibility of a fire travelling under a floor, behind matchboarding, or up a shaft. A fire extinguished in one place has often been known to start again elsewhere.

There is more than one side to every fire. Attack may be difficult on one side, and relatively easy on another.

Note.—A hat worn well forward will give some protection to the forehead against heat, and allow closer approach to the fire.

FIG. 15

FIG. 16

FIG. 17

ESCAPING THROUGH A WINDOW.

CPG 2-1A3
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 3

WHAT THE PLANNER NEEDS TO KNOW ABOUT FIRE IGNITION AND SPREAD

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

SOME JAPANESE EXPERIENCES

One might question at this point whether it is reasonable to assume that the survivors in a "low-risk" shelter facility can suppress ignitions and fires in an area damaged by a nuclear detonation. The most nearly parallel situation and, hence, best evidence comes from the nuclear attack on Hiroshima at the close of World War II. All of the evidence we have cited in this chapter suggests that the fire situation we must expect would be similar to that experienced at Hiroshima.

The upper photograph shows the Hiroshima branch of the Bank of Japan, a 3-story reinforced-concrete frame building of earthquake-resistant design. This building was only 1300 feet from ground zero, where an overpressure of about 18 psi occurred. About 100 people were in the bank at the time, of which about half were killed. Only four of the survivors are said to have been uninjured. Whether because the detonation was high above the building, whether because there were metal shutters at the windows, or whether because of effects of the blast wave, no initial ignitions occurred. About 1-½ hours afterward, a fire started in a room on the second floor from a firebrand. The nearest burning building was only 25 feet distant but the brand was said to come from nearby burning trees on another side. The survivors extinguished the blaze with water buckets, preventing further damage. A little later, a fire was started on the third floor. It was beyond control when discovered and the third floor burned out. But the fire did not spread to the lower floors.

The lower photograph shows another bank building, farther away, that experienced about 8 psi blast overpressure. Again, no initial ignitions were reported. However, at about 10:30 A.M., over 2 hours after the detonation, firebrands from the south exposure ignited a few pieces of furniture and curtains on the first and third stories. The fires were extinguished with water buckets by the building occupants. Negligible fire damage resulted.

These are but two of several examples of successful fire defense taken from the U.S. Strategic Bombing Survey report of events at Hiroshima. If one assumes that Americans can do what the unsuspecting residents of Hiroshima did, self-help measures by shelter fire-guard teams would appear to be effective.

PANEL 26

BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA

GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

PUBLIC CAPABILITIES FOR FIRE DEFENSE

In this country, self-help emergency firefighting by householders has been seen mainly in the periodic brush fires that plague central and southern California. This photograph of self-help firefighting is from the Oakland-Berkeley fire of 1970. People such as these have defended their homes from fire without training. The experience of the Forest Service suggests that the effectiveness of householders in fighting fire can be increased about 50 percent by modest training.

1. Move ignitable items, especially bedding, upholstered furniture, and rugs, to areas that would not be exposed to thermal radiation (about 1 man-hour required).

2. Cover or coat all windows with opaque materials, such as whitewash, paint, flour and water mixture, or aluminum foil (about 3 man-hours required).

3. Clean up garage, basement, and attic, disposing of loose combustible materials (about 1 man-hour required).

4. Clean up trash and ignitable items from exterior of house (about 3 man-hours required).

Extinguishment advice and training should emphasize use of garden hoses, wet mops and blankets, and sand or loose dirt to knock down ignitions to the point where smouldering items can be **carried or thrown outside, clear of the house.** Experiments conducted by the IIT Research Institute indicate that self-help extinguishment can be near 100 percent effective up to a minute or so before room flashover.

SOUTHWEST RESEARCH INSTITUTE
8500 Culebra Road, San Antonio, Texas 78206

Department of Structural Research
Fire Research Section

MASS FIRE LIFE HAZARD

A. J. Pryor
C. H. Yuill

FINAL REPORT

Prepared for
Office of Civil Defense
Department of the Army - OSA
under
Work Unit 2537A
through the
U. S. Naval Radiological Defense Laboratory
San Francisco, California 94135

Contract No. N228(62479)68665

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September 1966

It is estimated that about 40,000 of the 280,000 people in the Hamburg firestorm area were killed.[98] Considering the violence of a mass fire, it is remarkable that some 240,000 people survived a hazard which was never expected or even realized by most people.

There were four main types of shelters in Hamburg described as bunkers, splinterproof shelters, public cellar shelters, and private basement shelters. Survival in the bunkers and splinterproof shelters was high; in fact, Earp reports that all those sheltered in these types were unharmed (the U. S. Strategic Bombing Survey Reports[349, 352] and the Hamburg Police President's Report[164, 165] are cited as evidence).

Regarding the basement shelters, both private and public, Earp states:

> "No estimate is made in the various reports of the proportion of people who survived the raids in these shelters and were able to get out by their own efforts when the raids ceased. On reading the descriptions, perhaps somewhat highly coloured, of conditions in these shelters one is left with the impression of a very high proportion of casualties. However, since it is estimated ... that there were in the Hamburg fire-storm area some 227,000 people in communal or private cellar shelters of whom about 40,000 were killed, over 80 percent of the cellar shelterees must have been saved either through remaining in the shelters throughout the raid or by escaping to some safer place while there was yet time."[98]

The U. S. Strategic Bombing Survey[351] states:

> "Casualties in shelters (from air raids and resulting fires) were principally confined to apartment building shelters where personnel were often trapped by collapse or fire."

This agrees with Earp's statement and indicates that the majority of deaths in Hamburg occurred in basement shelters under buildings which burned and collapsed.

---

98. *Earp, K. F., "Deaths from Fire in Large Scale Air Attack with Special Reference to the Hamburg Fire Storm," Great Britain Home Office, Scientific Advisers' Branch, Report No. CD/SA 28, 1953.

164. *Kehrl, "Report by the Police President and Local Air Protection Leader of Hamburg on the Large Scale Raids on Hamburg in July and August 1943," December 1943, reprint by Office of Civil Defense, Washington 25, D. C., 1966.

165. *Kehrl, "Experiences in the Building of Air Raid Shelters," translated from Report by the Police President and Local Air Protection Leader of Hamburg on the Large Scale Air Raids on Hamburg in July and August 1943, by SRI, Menlo Park, Calif., 40 pp., 1966.

349. *U. S. Strategic Bombing Survey, "Fire Raids on German Cities," Physical Damage Division, War Department, Washington 25, D. C., October 1945.

351. *U. S. Strategic Bombing Survey, "Fire Raids on German Cities," Physical Damage Division, War Department, Washington 25, D. C., January 1947.

352. *U. S. Strategic Bombing Survey, "A Detailed Study of the Effects of Area Bombing on Hamburg," Area Studies Division, War Department, Washington 25, D. C.

Appendix 19 of the Police President's Report[165] contains brief information on thirty-three shelters in the Hamburg area. The appendix contains a description of each shelter and the fate of those who took shelter within. Nineteen of these shelters were identifiable by the present authors and have been plotted on a map of the Hamburg firestorm areas for the purpose of discussion. See Table 18 and Figure 23.

Of the nineteen shelters plotted, nine (possibly eleven) are within the firestorm area reported by Bond[30], five are within the area reported by the USSBS[351], and three are in the firestorm area reported by the Police President Kehrl[164]. Deaths are reported in nine of the thirty-three shelters; in six cases, the cause is concrete loosened by concussion or the direct hit of a high explosive bomb; and, in three cases, the cause of death is reported as the result of fire. Seven of these nine shelters have been plotted, and it should be noted that all three shelters with fire deaths (Nos. 9, 10, and 11) are definitely not located within the fire zones (those marked by a ▲ could not be located precisely, although they are on the correct street). It is possible that the three shelters with fire deaths could all be located within the firestorm areas reported by both Bond and the USSBS, for there is an overlap which could possibly satisfy the adresses of all three shelters. Two of the six shelters reported as having deaths due to falling concrete (Nos. 24 and 28) are located within the area noted by both Bond and USSBS and are reported as having two occupants killed in one and three in the other. Shelter No. 20, also one of the six reported as having deaths due to falling concrete, is located within an area noted by both Bond and the Police President Kehrl as a firestorm area. Three shelters reported by both references in the firestorm area had no deaths or injuries (Nos. 12, 19 and 26).

Of the reported shelters, ten are classed as splinterproof types, seven as bunkers, six as private, and nine as public shelters. The fire deaths all occurred in public shelters. This loosely agrees with Earp's conclusions that no fire deaths occurred in bunkers or splinterproof shelters. The fact that no deaths are reported by fire in nine of the twelve shelters in the firestorm areas reported by Bond, USSBS, and Police President Kehrl is evidence of the survival possibilities.

Appendix 19 of the Hamburg Police President's Report[165] cites several shelter incidents where fire bombs completely destroyed a building directly over a shelter and the occupants were safely protected. Such cases are reported in private shelters as well as bunkers (see Table 18).

It has been estimated[98] that the survival of 240,000 people (out of 280,000 estimated to be present) in the Hamburg firestorm area "might be accounted for as follows (see also discussion on page 109):

Rescued by Police, Medical, Rescue and Armed Forces	30,000
Rescued by Fire and Decontamination Services	15,000
Survived in nonbasement shelters (100 percent of occupants)	53,000
Survived in basement shelters or escaped by their own initiative	142,000
	240,000"

30. *Bond, H. [Ed.], Fire and the Air War, National Fire Protection Association, Boston, Mass., 262 pp., 1946.

Source: See Refs. 30, 164

FIGURE 23. SHELTERS IN HAMBURG FIRESTORM AREAS

URS 7004

FINAL REPORT

FIRE FIGHTING OPERATIONS IN HAMBURG, GERMANY DURING WORLD WAR II

OCD Contract No. DAHC20-70-C-0307 Work Unit 2534H

Prepared for:

OFFICE OF CIVIL DEFENSE
Office of the Secretary of the Army
Washington, D.C. 20310

By:

Carl F. Miller

June 1971

URS RESEARCH COMPANY

155 Bovet Road, San Mateo, California 94402

A URS Systems Affiliate

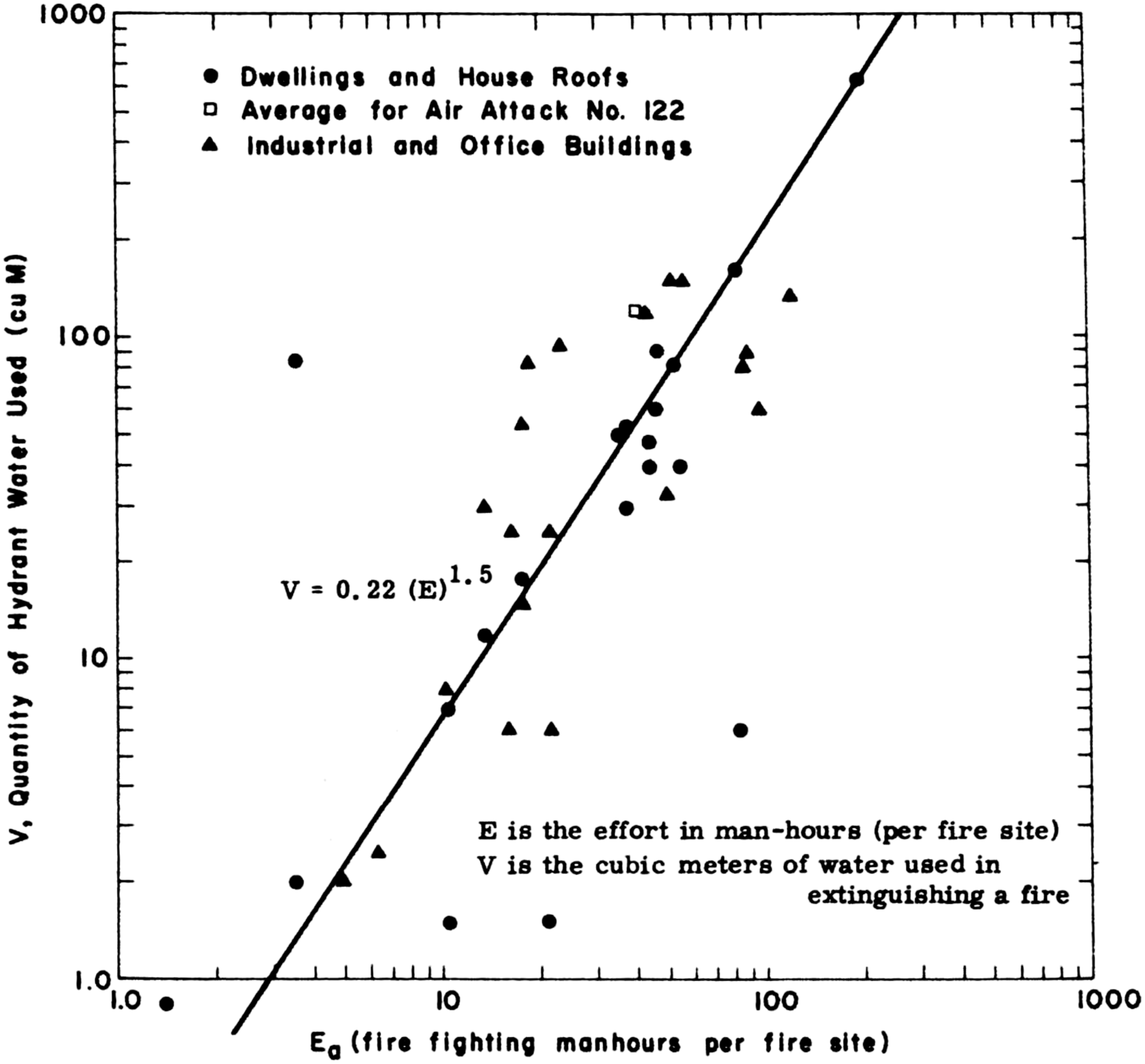


Figure 4: Hamburg Fire Department Hydrant Water Use During the Fighting of Air Raid Caused Fires

IMPLICATIONS OF THE HAMBURG WORLD WAR II DATA ON CURRENT CIVIL DEFENSE PLANNING

As soon as MIRV capabilities become operational realities,[10] the greater possibility of the use of relatively low nuclear yield weapons in nuclear arsenals would make the experiences of Hamburg and of Hiroshima and Nagaski more applicable to direct interpretation for civil defense purposes. For these situations and perhaps even for the situation where larger nuclear detonations are involved, some of the basic concepts of fire fighting when area fires develop would be theoretically applicable to the current situation (providing the water problem described above would not be a controlling factor--i.e., water is provided through other means).

A Hamburg Fire Department group leader reported after the third large attack on July 30, 1943, that: "The experiences from this air attack proved once again that assignment of fire fighting forces within the confines of the fire area is useless and, further, such assignments are impossible because of the inability to move on surface streets" (because of the debris and bomb craters). "One exception, of course, is the deployment for rescue to save human lives."

In the large scale air attacks on Hamburg, the professional fire fighting forces, perhaps larger on a per-capita or per-structure basis than for a modern city, was able to fight only at about 5 to 10 percent of the fire sites even after three years of responding to air-raid-caused fires. Without extrapolating to worse conditions for the nuclear attack case, it doesn't appear that the professional fire fighting units could, with highest possible effort, change the fire damage statistics very much for a nuclear attack on a city. However, the rather surprising high relative performance of the Self-Protection Service units of Hamburg even through the heavy attack and large area fires on 7/25/43 indicates the possibility for a fire fighting force whose efforts could influence the fire damage statistics in a nuclear attack on cities.

While the purpose of a self-help fire fighting service for the nuclear situation might be almost identical to that laid down for the Self-Protection Serivce organization of Hamburg--the suppression or extinguishment of small fires as rapidly as possible and before they become too large to be extinguished by any group--the nuclear attack case would involve putting out fires already ignited in exposed fuels whereas the World War II case

Second, the relatively high performance rate of the Self-Protection Service groups suggests that the non-professional citizen, with a small amount of training, guidance, equipment, leadership, and perhaps coercion, could contribute statistically to the reduction of fire damage in a nuclear war. The debris, the likely lack of water, and the apparent lack of a sufficient number of personnel would deny the professional fire fighting units, by themselves, the opportunity of making any statistically-countable contributions to the reduction of fire damage in a nuclear attack on American cities.

On the basis of information given in the Hamburg Fire Department Documents and by Schubert,[6] the relative strength of the Hamburg professional fire fighting forces in July of 1943 was 2.34×10^{-3} firemen per capita. Census information indicates that the relative strength of the professional fire fighting forces in the United States was as follows:

Average for Entire U.S. (1960):	0.77×10^{-3} firemen/capita
Average for Entire U.S. (1966):	0.88×10^{-3} firemen/capita
Average for All U.S. Cities (1966):	1.33×10^{-3} firemen/capita
Average for U.S. Cities with more than 50,000 people (1966):	1.71×10^{-3} firemen/capita

These relative strengths, of course, are only very qualitative indicators of the relative capabilities of the fire fighting forces of U.S. cities to cope with mass fires as was done in 1943 by the Hamburg Fire Department. The size of the urban area per fire fighting unit, the number and type of structures in that area, and the availability of modern equipment and methods would be additional factors that must be considered. The qualitative indicators, together with the likely additional constraints on fire fighting operations that could arise in the nuclear attack case, however, suggest that the relative strength of professional fire fighting forces of the U.S. cities would be less sufficient for that case than were the forces of the Hamburg Fire Department in fighting the fires in Hamburg in July and August of 1943.

10. Miller, Carl F., Assessment of Nuclear Weapon Requirements For Assured Destruction, URS Research Company Report URS 757-6, February 1970

11. Miller, Carl F., Civil Defense Operational Concepts, URS Research Company Report URS 757-1, May 1969

Multiple Warheads on Ballistic Missiles (U), Strategic Planning Group, Army Map Service, February 1960. (TS-RD)

AD 680 459

APPENDIXES 1 THROUGH 7 TO THE HAMBURG POLICE PRESIDENT'S REPORT ON THE LARGE SCALE AIR ATTACKS ON HAMBURG, GERMANY, IN WORLD WAR II

Contract No. NOO228-67-C-1519
OCD Work Unit No. 2536D

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

NRDL-TRC-68-47

APPENDIXES 1 THROUGH 7 TO THE HAMBURG POLICE PRESIDENT'S REPORT ON THE LARGE SCALE AIR ATTACKS ON HAMBURG, GERMANY, IN WORLD WAR II

Prepared by:

Carl F. Miller

SRI Project No. MU-6464

Contract No. NOO228-67-C-1519
OCD Work Unit No. 2536D

Prepared for:

OFFICE OF CIVIL DEFENSE
OFFICE OF THE SECRETARY OF THE ARMY
WASHINGTON, D.C. 20310

December 1968

Through:

CIVIL DEFENSE TECHNICAL GROUP
U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
SAN FRANCISCO, CALIFORNIA 94135

INSTRUCTIONS FOR THE EFFICIENT CONSTRUCTION OF AIR-RAID SHELTERS

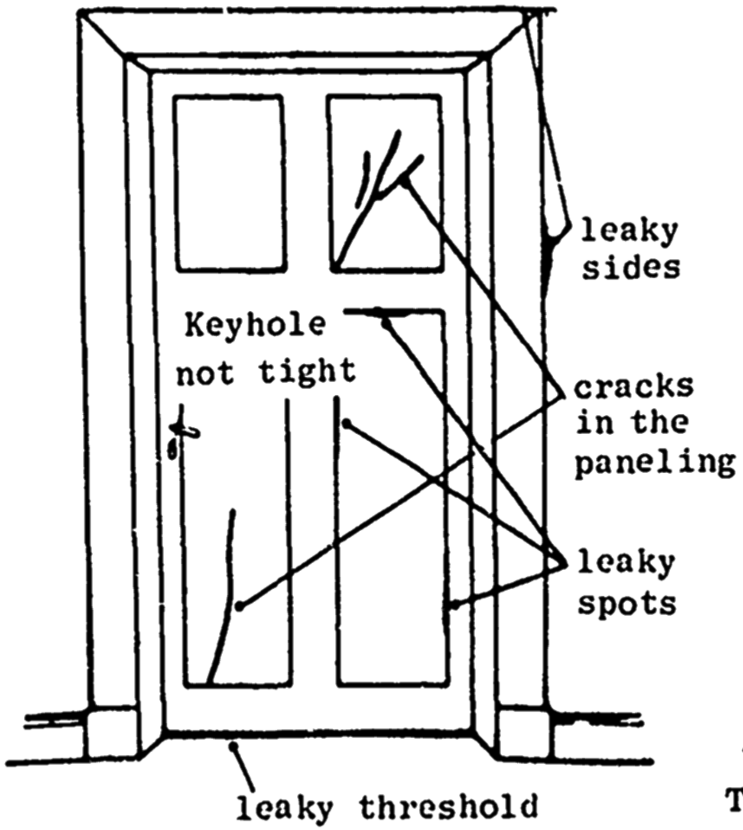
Published by the Police President of Hamburg

3. Protection against Poison Gas (also for Carbon Monoxide)

Every shelter must be secured against poison gas as well as against flying debris. This protection is achieved through sealing of all openings (cracks in walls, doors, windows, keyholes, pipelines, etc.) Shown below is a door made secure by pasting on paper. All cracks are to be closed by cement or shredded paper soaked in water. Be sure to fix cracks on top of doors.

Not Like This

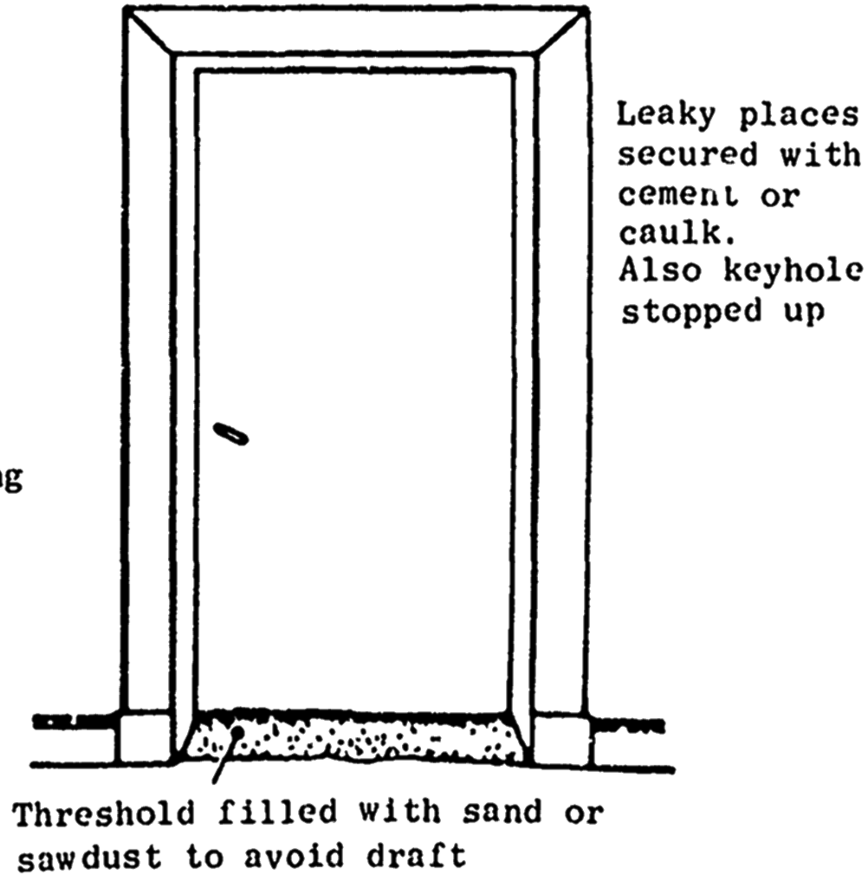
Securing against Gas Seepage



Picture 7

But Like This

The Proper Way



Picture 8

RESEARCH TRIANGLE INSTITUTE
Durham, North Carolina

Final Report R-85-1

CRASH CIVIL DEFENSE PROGRAM STUDY

by

K. E. Willis
E. R. Brooks
L. J. Dow

April 30, 1963

Prepared for

OFFICE OF CIVIL DEFENSE
UNITED STATES DEPARTMENT OF DEFENSE

Feasibility

In the typical household, some materials will generally be available for covering windows against thermal radiation. One half roll of aluminum foil would cover about 25 ft^2 and would provide very effective covering for 1 to 2 windows (those most likely to face the blast). Sufficient quantities of either light colored paint, Bon Ami, or whiting would be available in most households to cover windows. Aluminum screens attenuate from 30 - 50% of the thermal radiation and hence screens should be closed or installed.

The amount of water per square foot required to dissipate 25 cal/cm^2 of thermal radiation can quickly be calculated from the heat of vaporization of water (580 cal/gm). Allowing 90% losses due to absorption or spillage, one gallon of water is sufficient to wet 10 ft^2 of material so that it can withstand 25 cal/cm^2 of direct thermal radiation (i.e., the radiation is normal to the material surface at all points). Since the average daily water consumption per service (Reference 3) is about 700 gallons, it is apparent that the wetting of interior flammables (piled up curtains, furniture, etc.) is feasible in most cases when used in conjunction with the other measures.

3. Statistical Abstracts of the United States. Washington: U. S. Government Printing Office, 1962.

~~CONFIDENTIAL~~

DEPARTMENT OF THE ARMY TECHNICAL MANUAL — TM 23-200

DEPARTMENT OF THE NAVY — OPNAV INSTRUCTION 03400.1B

DEPARTMENT OF THE AIR FORCE — AFL 136-1

MARINE CORPS PUBLICATIONS — NAVMC 1104 REV

CAPABILITIES OF ATOMIC WEAPONS (U)

Prepared by
Armed Forces Special Weapons Project

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE

REVISED EDITION NOVEMBER 1957

~~CONFIDENTIAL~~

c. Indirect Blast Injury.

(1) *General.* Indirect blast casualties result from burial by debris from collapsed structures with attendant production of fractures and crushing injuries, from missiles placed in motion by the blast wave, or from fire or asphyxiation where individuals are prevented from escaping the wreckage.

(2) *Personnel in structures.* A major cause of personnel casualties in cities is structural collapse and damage. The number of casualties in a given situation may be reasonably estimated if the structural damage is known. Table 6–1 shows estimates of casualty production in two types of buildings for several damage levels. Data from Section VII may be used to predict the ranges at which specified structural damage occurs. Demolition of a brick house is expected to result in approximately 25 percent mortality, with 20 percent serious injury and 10 percent light injury. On the order of 60 percent of the survivors must be extricated by rescue squads. Without rescue they may become fire or asphyxiation casualties, or in some cases be subjected to lethal doses of residual radiation. Reinforced concrete structures, though much more resistant to blast forces, produce almost 100 percent mortality on collapse. The figures of table 6–1 for brick homes are based on data from British World War II experience. It may be assumed that these predictions are reasonably reliable for those cases where the population is in a general state of expectancy of being subjected to bombing and that most personnel have selected the safest places in the buildings as a result of specific air raid warnings. For cases of no prewarning or preparation, the number of casualties is expected to be considerably higher. To make a good estimate of casualty production in structures other than those listed in table 6–1, it is necessary to consider the type of structural damage that occurs and the characteristics of the resultant missiles. Glass breakage extends to considerably greater ranges than almost any other structural damage, and may be expected to produce large numbers of casualties at ranges where personnel are relatively safe from other effects, particularly for an unwarned population.

Table 6–1. Estimated Casualty Production in Structures for Various Degrees of Structural Damage

	Killed outright	Serious injury (hospitalization)	Light injury (No hospitalization)
1–2 story brick homes (high explosive data):	*Percent*	*Percent*	*Percent*
Severe damage	25	20	10
Moderate damage	<5	10	5
Light damage	------	<5	<5
Reinforced-concrete buildings (Japanese data, nuclear):			
Severe damage	100	------	------
Moderate damage	10	15	20
Light damage	<5	<5	15

Note. These percentages do not include the casualties which may result from fires, asphyxiation, and other causes from failure to extricate trapped personnel. The numbers represent the estimated percentage of casualties expected at the maximum range where the specified structural damage occurs.

Personnel in a prone position are less likely to be struck by flying missiles than those who remain standing.

Table 6–2. Critical Radiant Exposures for Burns Under Clothing

(Expressed in cal/cm² incident on outer surface of cloth)

Clothing	Burn	1 KT	100 KT	10 MT
Summer Uniform	1°	8	11	14
(2 layers)	2°	20	25	35
Winter Uniform	1°	60	80	100
(4 layers)	2°	70	90	120

CUE

FOR SURVIVAL

OPERATION CUE

A. E. C. NEVADA TEST SITE

MAY 3, 1955

A REPORT BY THE

FEDERAL CIVIL DEFENSE

ADMINISTRATION

EFFECTS OF NUCLEAR WEAPONS

BY HAROLD L. GOODWIN,
Director, Atomic Test Operations, FCDA

A great deal of information has been released over the past several years on the effects of atomic explosions, yet many of these effects are still poorly understood by the general public. For that reason, the principal effects of a nuclear explosion are reviewed, with a brief discussion of factors of particular importance to civil defense.

This entire section is based on informaton available in published sources. There is a widespread but erroneous view that most information on the effects of nuclear explosions is classified, and hence is not available to the general public. Information that exists only in classified form generally is information which deals with refinements of weapons effects. A considerable amount of gross information on any major effect is available in a number of publications.

The best reference in this field is still the basic handbook, *The Effects of Atomic Weapons.* Despite the fact that this useful work was first published in 1950, queries daily to the Federal Civil Defense Administration indicate that it has not been widely studied or understood. A thoughtful reading will be of value to any person with civil defense responsibility. A revision, now in process, may be issued in the next few months.

The time of travel of the shock wave is not generally understood by many persons. The concept of "duck and cover," which would still be of great value in case of attack without warning, is based on the comparatively large time interval between the burst and arrival of the shock wave at a given point.

It takes several seconds for the shock wave of a nominal bomb to reach a point 2 miles from the burst. A person who moved promptly at the first light of the detonation would have time to get under or behind a convenient piece of furniture, or other protection. At greater distances there would be even more time.

This time lapse between the detonation and arrival of the shock wave was graphically demonstrated to persons watching from the observer areas in the Test Site. The detonation takes place, a phenomenon without sound from the viewpoint of the observer. So much time elapses between the detonation and arrival of the shock wave that observers sometimes forget that the shock wave is on its way and the loud bang of its arrival finds them unprepared. Persons are frequently startled and have even been pushed off balance by the shock wave. The pause between a lightning flash and the thunder is comparable.

The question may be asked, how will one know when a burst has gone off if the sound does not arrive for some time? The answer is that the light from the explosion is its own warning.

BIOMEDICAL EFFECTS OF THERMAL RADIATION

BY DR. HERMAN ELWYN PEARSE, *Professor of Surgery at the University of Rochester. Consultant to several Government departments, notably the Atomic Energy Commission's Division of Biology and Medicine. Consultant to the Armed Forces Special Weapons Project*

After the Bikini test, I was asked to go to Japan as a consultant for the National Research Council to survey the casualties in Nagasaki and Hiroshima. Being a surgeon, I was greatly impressed with the magnitude of the medical problem from burns and wounds very largely caused by flying missiles. They constituted roughly 85 percent of the casualties in Japan.
140

In Japan it was an August day, the people were lightly clothed, and they were out in the open.
141

Then we observed the healing of the wounds, and we found again that the wounds healed in the same manner as those that we had produced in the laboratory. There was some difference in these lesions from the ordinary burns of civil life, but I would predict, from what I learned from experiments, that the difference is on the good side. The burns look worse; they are often charred, but they may not penetrate as deeply, and the char acts as a dressing, nature's own dressing. The scab solidifies, and the healing process goes on under that scab, after which the scab is sequestrated, and the healed surface is revealed beneath.
142

I didn't care what happened to the fabrics; I wanted to know what happened to the man under the fabric. So we conceived this idea, that the important factor in studying clothing was what happened under the clothing; how it shielded the animal with cloth of different composition, weight, texture, weave, and color. We have made a great many studies both in the laboratory and in the field on this problem of the protective effect of clothing....

For example, if you have 2 layers, an undershirt and a shirt, you will get much less protection than if you have 4 layers; and if you get up to 6 layers, you have such great protection from thermal effects that you will be killed by some other thing. Under 6 layers we only got about 50 percent first degree burns at 107 calories.
143

If we can just increase the protection a little bit, we may prevent thousands and thousands of burns.

... For example, to produce a 50-percent level of second-degree burns on bare skin required 4 calories. When we put 2 layers of cloth in contact, it only took 6 calories. But separate that cloth by 5 millimeters, about a fifth of an inch, and it increases the protective effect 5 times. The energy required to produce the same 50-percent probability of a second-degree burn is raised up to 30 calories. So if you wear loose clothing, you are better off than if your wear tight clothing.
144

UR-261

Health and Biology

THE UNIVERSITY OF ROCHESTER
Atomic Energy Project
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Rochester 20, New York

Contract W-7401-eng-49

* * *

STUDIES ON FLASH BURNS: THE PROTECTION AFFORDED BY 2, 4 AND 6 LAYER FABRIC COMBINATIONS

by:

George Mixter and Herman E. Pearse

Division: Special Programs

Division Head: H. A. Blair

Section: Flash Burn

Section Head: H. D. Kingsley

Submitted by: Henry A. Blair, Director

Date of Report: 6/4/53

STUDIES ON FLASH BURNS:

THE PROTECTION AFFORDED BY 2, 4 AND 6 LAYER FABRIC COMBINATIONS

by

George Mixter, Jr., M. D. and Herman E. Pearse, M. D.

ABSTRACT

Fabric interposed between a carbon arc source and the skin of Chester White pigs increased the amount of thermal energy required to cause 2+ burns. For the 2, 4 and 6 layers of fabric studied this increase was 3.6, 38 and over 104 cal/cm^2 respectively when the inner layer of fabric was in contact with the skin. Separation of the inner layer from the skin by 5 mm increased the protective effect of the 2 layer combination from 7.4 to 29 cal/cm^2, provided the outer layer was treated for fire retardation. If the outer layer was not so treated, sustained flaming occurred which in itself added to the thermal burn.

INTRODUCTION

In the past, work in this laboratory has been directed toward a study of flash burns in unshielded skin. It is well known from the atomic bombing in Japan that this type of burn was modified by clothing. A laboratory analysis of the protective effect of fabrics against flash burns was begun (5) by shielding the skin with a few representative fabrics and their combinations.

1. 2 Layers
   a. light green oxford
      knitted cotton underwear
   b. light green oxford (HPM)
      knitted cotton underwear
2. 4 Layers
   olive green sateen
   thin cotton oxford
   wool-nylon shirting
   knitted cotton underwear
3. 6 Layers
   olive green sateen
   thin cotton oxford
   mohair frieze
   rayon lining
   wool-nylon shirting
   knitted wool underwear

5. Morton, J. H., Kingsley, H. D., and Pearse, H. E., "Studies on Flash Burns: The Protective Effects of Certain Fabrics", Surgery, Gynecology and Obstetrics, 94, 497-501 (April 1952).

Clothing protects back, 1 mile from ground zero Hiroshima, aged 17.
Photo taken October 1945. Unclothed arms burned facing burst.

Above and below: clothing fails to ignite on mannequins located at 7000 feet from ground zero, 29 kt Teapot-Apple 2, 5 May 1955.

Addendum No. 1

for

DNA 1240H-2, Part 2

HANDBOOK OF UNDERWATER NUCLEAR EXPLOSIONS

21 January 1974

M. J. Dudash
DASIAC
General Electric Company–TEMPO
816 State Street
Santa Barbara, CA 93102

19 August 1973 CHAPTER 18

18.7 THERMAL AND NUCLEAR RADIATION EFFECTS ON SURFACE SHIP PERSONNEL

18.7.1 Casualty and Risk Criteria

Table 18-2

CDC NUCLEAR AND THERMAL RADIATION CRITERIA

New Thermal Radiation Criteria

Risk Criteria for Burns Under Summer Uniforms to Warned, Exposed Personnel

	% Incidence	Mechanism	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
Negligible	2.5	1° burn	3.1	4.2	5.8
Moderate	5	1° burn	3.7	5.0	6.8
Emergency	5	2° burn	6.3	8.8	12

	Casualties due to 2nd Degree Burns			
Time to Ineffectiveness	% Incidence	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
24. hr	50	38	53	73

Personnel Risk and Casualty Criteria for Nuclear Weapons Effects
ACN 4260, U. S. Army Combat Developments Command Institute of Nuclear Studies, August 1971

WESTERN AUSTRALIA.

CIVIL DEFENCE COUNCIL

AIR RAID PRECAUTIONS

HANDBOOK No. 8.

The Duties of Air Raid Wardens

(REVISED EDITION 1941)

Issued by Authority of the Civil Defence Council.

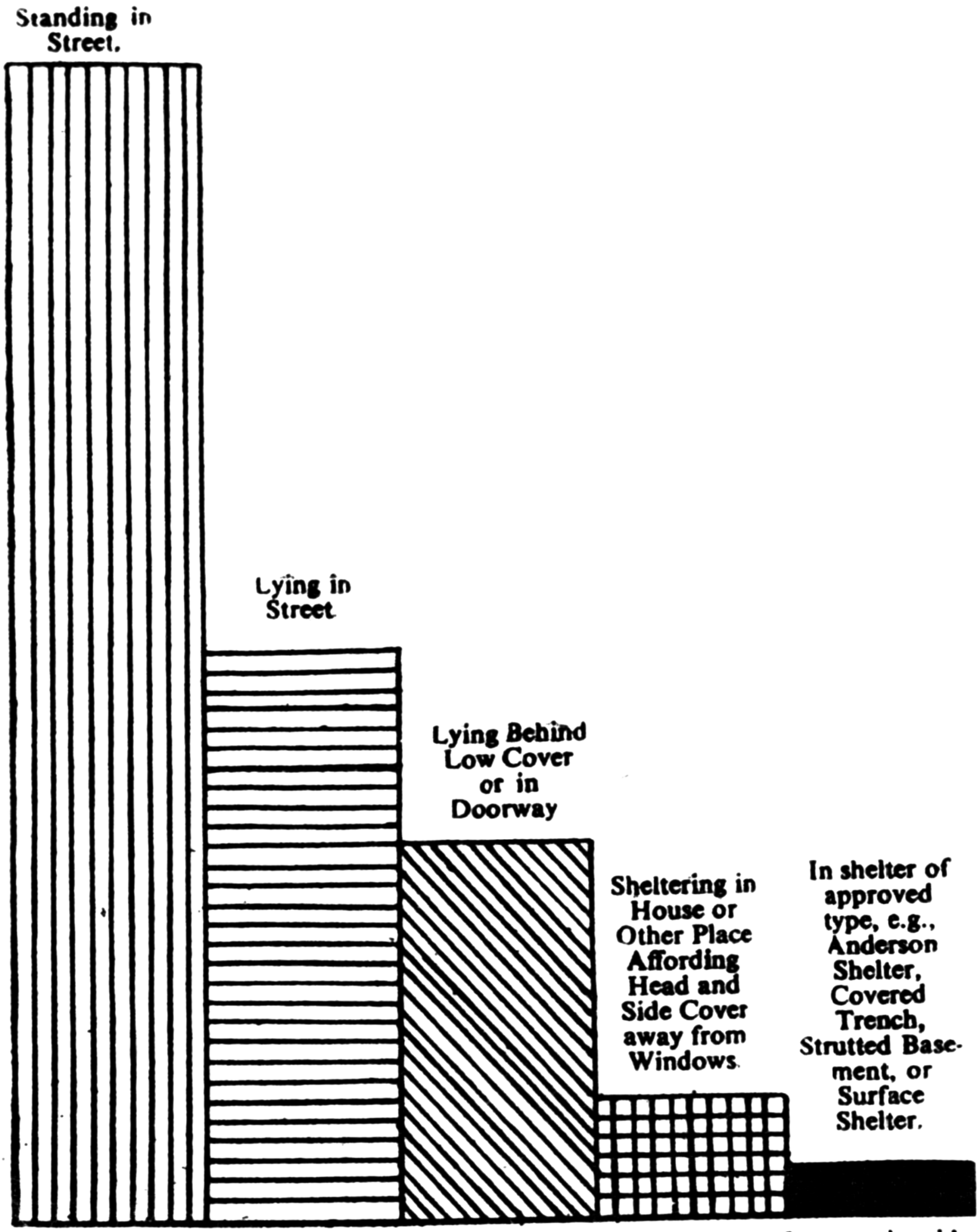
PERTH:

BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

1941.

1088/41.

The following diagram is appended to illustrate the relative degree of protection afforded by the open street, by door-ways, by the interior of ordinary dwellings, and by simple shelters of approved design:—



This diagram is based on a large number of reports of the results of recent air raids and is an approximate indication of the difference in the degree of risk resulting from taking cover in various ways

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OFFICE OF THE CHIEF SCIENTIFIC ADVISER

A COMPARISON BETWEEN THE NUMBER OF PEOPLE KILLED PER TONNE OF BOMBS DURING WORLD WAR I AND WORLD WAR II

BOMB SIZES

=> ≈ 175 kg

For World War II the average bomb weight was between 150 - 200 kg. (R.C. 268, Table 6), whereas for World War I the majority of bombs were 12 or 50 kg.

TABLE 5

Relative safeties in World War II deduced from population and casualty distribution

	In the open	Under cover	In shelter
Population exposure	5%	60%	35%
Location people killed	19%	62%	19%
Relative safety	72%	20%	10%
RELATIVE DANGER!			

(1) A house about 3½ times as safe as in the open.
(2) A shelter about twice as safe as a house.

Table 6 also shows the location of killed which is implied by each of the possible population exposures. The only evidence available on this point is that, for the day raid on June 13th, 1916, in which the total number killed was 59, 69.5% of the people killed in the City were in the open.

HOME OFFICE

THE PROTECTION OF YOUR HOME AGAINST AIR RAIDS

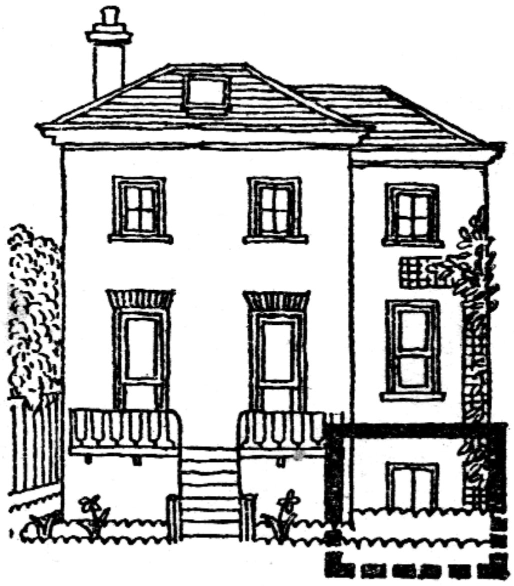
READ THIS BOOK THROUGH

THEN

KEEP IT CAREFULLY

HOW TO CHOOSE A REFUGE-ROOM

Almost any room will serve as a refuge-room if it is soundly constructed, and if it is easy to reach and to get out of. Its windows should be as few and small as possible, preferably facing a building or blank wall, or a narrow street. If a ground floor room facing a wide street or a stretch of level open ground is chosen, the windows should if possible be specially protected (see pages 30 and 31). The stronger the walls, floor, and ceiling are, the better. Brick partition walls are better than lath and plaster, a concrete ceiling is better than a wooden one. An internal passage will form a very good refuge-room if it can be closed at both ends.

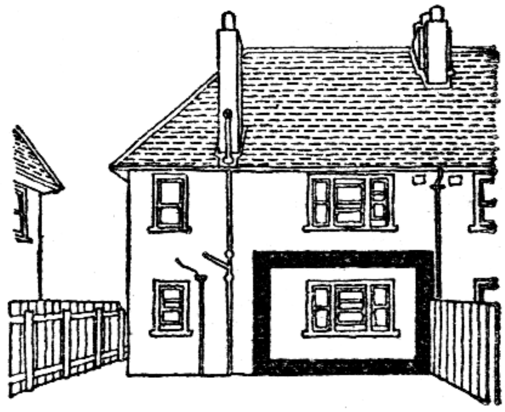


A cellar or basement is the best position for a refuge-room if it can be made reasonably gas-proof

The best floor for a refuge-room

A cellar or basement is the best place for a refuge-room if it can be made reasonably gas-proof and if there is no likelihood of its becoming flooded by a neighbouring river that may burst its banks, or by a burst water-main. If you have any doubt about the risk of flooding ask for advice from your local Council Offices.

Alternatively, any room on any floor below the top floor may be used. Top floors and attics should be avoided as they usually do not give sufficient protection overhead from small incendiary bombs. These small bombs would probably penetrate the roof but be stopped by the top floor, though they might burn through to the floor below if not quickly dealt with.

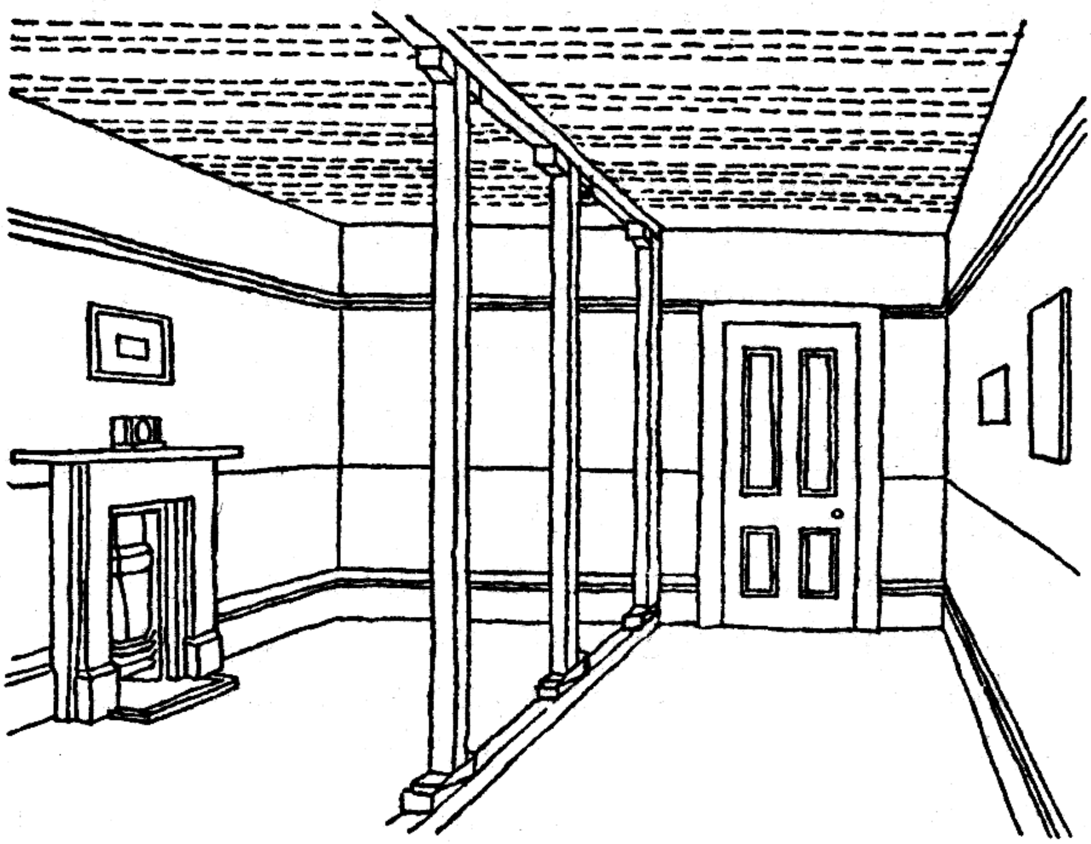


In a house with only two floors and without a cellar, choose a room on the ground floor so that you have protection overhead

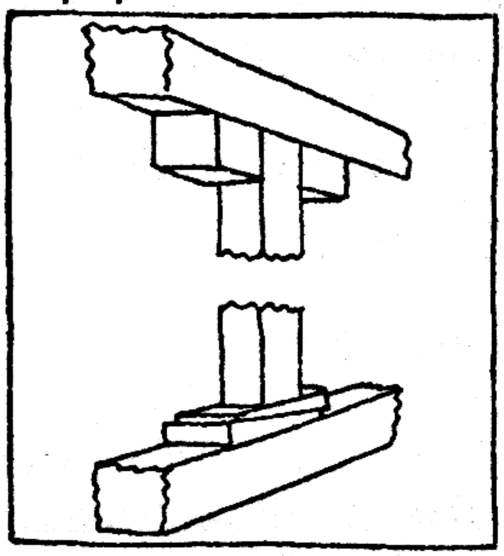
Strengthening the room

If your refuge-room is on the ground floor or in the basement, you can support the ceiling with wooden props as an additional protection. The illustration shows a way of doing this, but it would be best to take a builder's advice before setting to work. Stout posts or scaffold poles are placed upright, resting on a thick plank on the floor and supporting a stout piece of timber against the ceiling, at right angles to the ceiling joists, i.e. in the same direction as the floor boards above.

How to support a ceiling



The illustration below shows the detail of how to fix the props

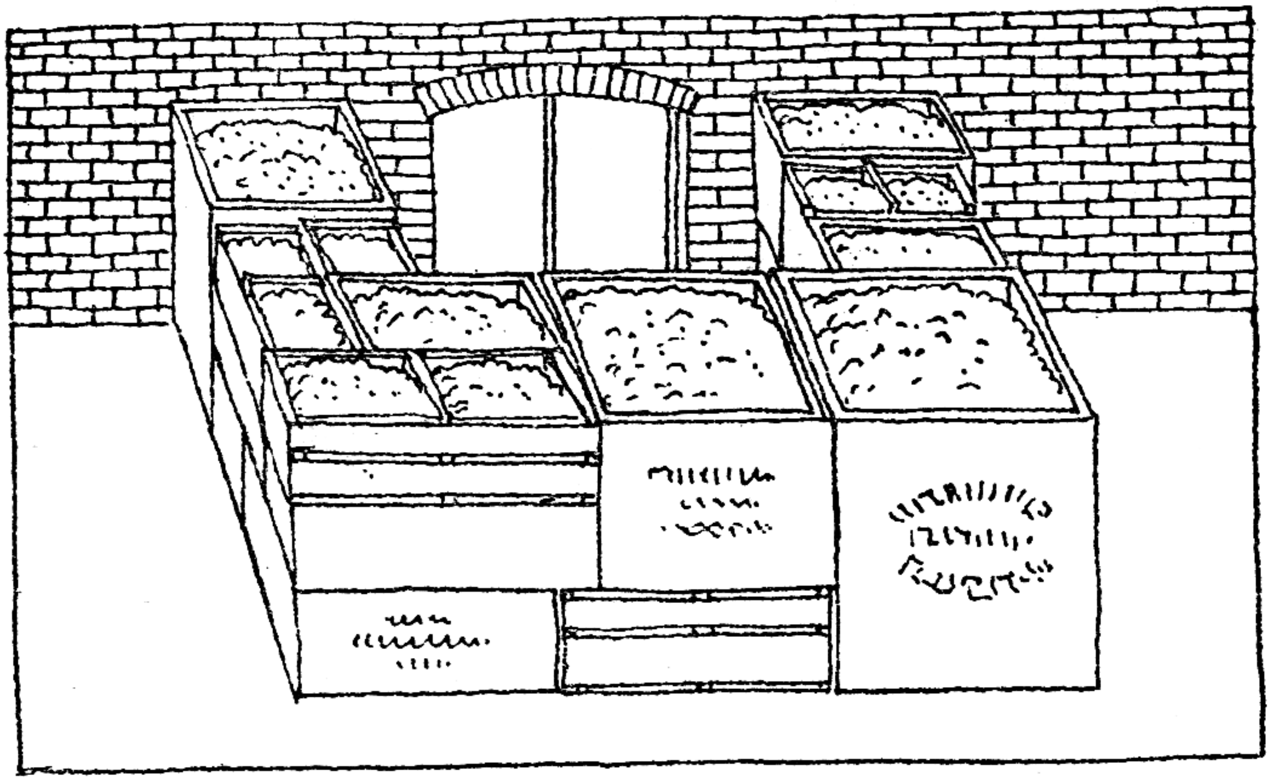


The smaller illustration shows how the posts are held in position at the top by two blocks of wood on the ceiling beam. The posts are forced tight by two wedges at the foot, driven in opposite ways. Do not drive these wedges too violently, otherwise you may lift the ceiling and damage it. If the floor of your refuge-room is solid, such as you might find in a basement, you will not need a plank across the whole floor, but only a piece of wood a foot or so long under each prop.

EXTRA PRECAUTIONS AGAINST EXPLOSIVE BOMBS

TRENCHES. Instead of having a refuge-room in your house, you can, if you have a garden, build a dug-out or a trench. A trench provides excellent protection against the effects of a bursting bomb, and is simple to construct. Full instructions will be given in another book which you will be able to buy. Your air raid wardens will also be able to advise.

SANDBAGS. Sandbags outside are the best protection if your walls are not thick enough to resist splinters. Do not rely on a wall keeping out splinters unless it is more than a foot thick. Sandbags are also the best protection for window openings. If you can completely close the window opening with a wall of sandbags you will prevent the glass being broken by the blast of an explosion, as well as keeping out splinters. But the window must still be sealed inside against gas.



A basement window protected by boxes of earth

Any bags or sacks, including paper sacks such as are used for cement, will do for sandbags. But if they are large, don't fill

ALL persons involved in accidents suffer from shock, whether or not they suffer physical injury. Shock is a disturbance of the nervous system. It varies in its severity. The signs of shock are faintness, paleness, weak pulse, and weak breathing.

TREATMENT OF SHOCK

1 Place the patient flat on his back on a bed or a rug or on cushions. If you think a bone may be broken do not move the patient more than can be helped.

2 Loosen the clothing at the neck, chest and waist to make the breathing freer.

3 Cover the patient warmly with rugs and blankets. In cases of shock the body loses heat. A hot-water bottle is helpful, but take care that it does not lie in contact with the skin.

4 Give hot drinks. If you cannot make hot drinks, give cold water *in sips*. But only if the patient is conscious and able to swallow.

5 Soothe the patient by speaking reassuring words in a calm voice and in a confident way.

TREATMENT OF WOUNDS

The first thing to do is to stop the bleeding and to keep the wound clean. This can be done by covering it with a clean dressing bound on tightly. Do not touch a wound with your fingers because of the risk of poisoning from dirt. Treat the patient for shock in addition to attending to the wound, because the loss of blood, if the wound is serious, and the pain do in themselves cause shock.

WOUNDS IN THE HEAD AND BODY

1 Cover the wound with a clean folded handkerchief or a double layer of dry lint.

2 Apply another handkerchief or a layer of cotton wool as a pad to distribute the pressure over the wound.

3 Tie the dressing in position with a bandage, a strip of linen, or a necktie. This can be done quite firmly, unless there is any foreign body, especially glass, in the wound, or unless the bone is broken. In this case the dressing should be tied on lightly.

4 Treat the patient for shock.

3rd October, 1963.

~~RESTRICTED~~ 9/7/89 For PRO

HOME OFFICE

SCIENTIFIC ADVISER'S BRANCH

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RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

This research, consisting of a series of model experiments, has demonstrated that the risk from blast in the tubes would be less than the risks above ground. The results are considered to be consistent enough to provide a good estimate of full-scale conditions, and reliable enough to be used as a basis for Home Office shelter policy regarding the London tube railways.

Introduction

When the Advisory Group on Structural Research for Civil Defence was formed in 1957, the Chairman recommended that a study of the effects of blast on tunnels should be one of the main research projects. The relevant paragraphs of his proposals(1) for a research programme were:-

> "In any consideration of tunnels as shelter the crucial problem is the entry of blast, either through existing openings or from a crater formed by a ground-burst bomb. It is particularly important to know if the collapse of a tunnel by earth shock would prevent the blast from entering it, and also whether the collapse would provide a seal against the entry of water from the crater. It is probable that some data could be derived from model experiments using H.E. charges. But it is for consideration whether the results would be so conclusive that the behaviour of full-size tunnels when damaged by megaton weapons could be forecast with the confidence that a major shelter programme would demand."

At the second meeting(2) the Group agreed that model experiments with H.E. charges would be worthwhile, and that the Atomic Weapons Research Establishment (A.W.R.E.) should carry out this research, which has now been accepted by the Advisory Group as successfully completed. A summary record of the progress follows.

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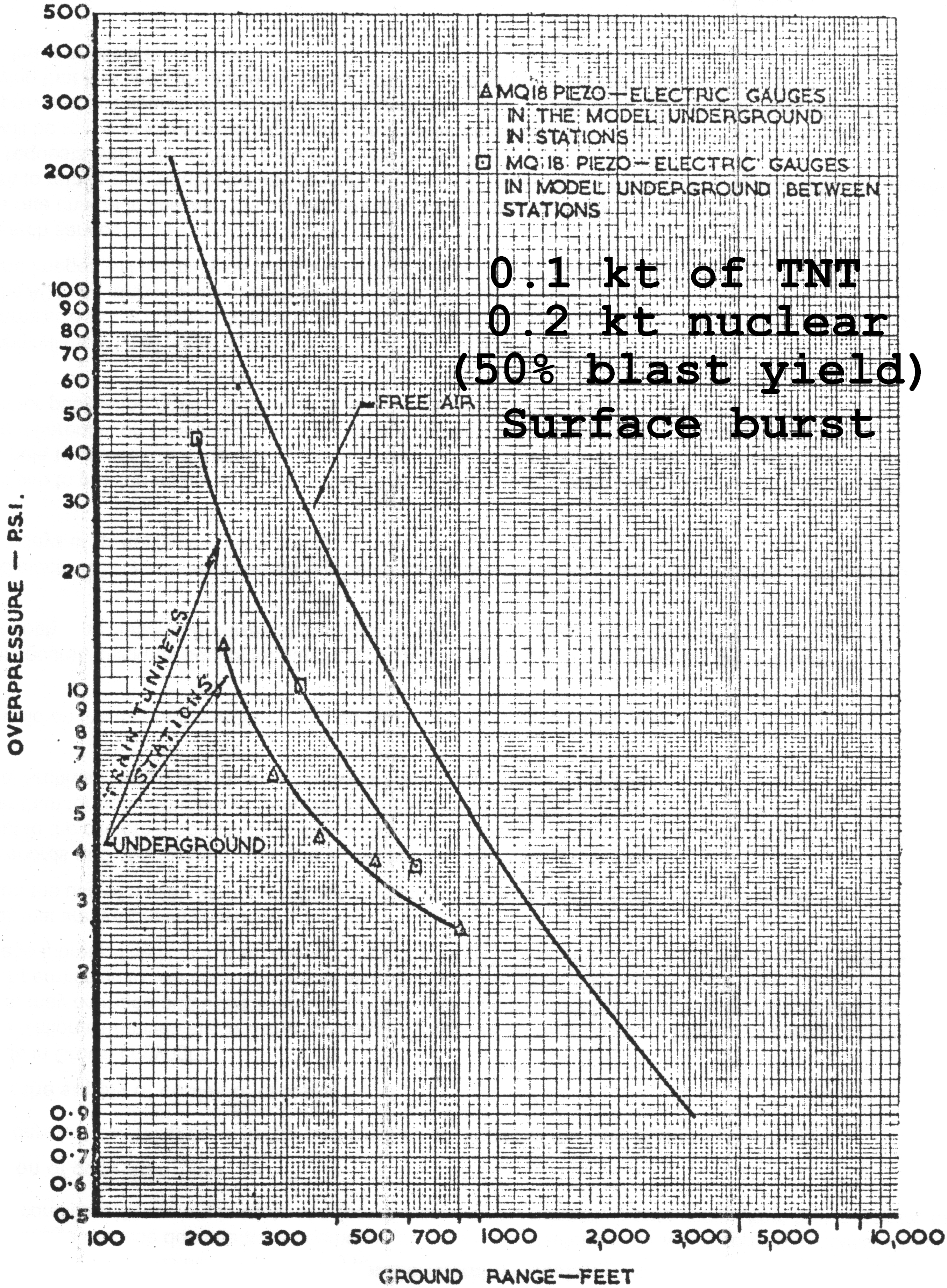
100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961



Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

These trials are described in a preliminary report[5] prepared for the Advisory Group by A.W.R.E. It was shown that the blast pressure inside a tunnel system, having openings at intervals to ground level, is less than the pressure at ground level at any distance from the explosion, by a factor of about 3. This reduction in pressure was apparently caused by the station entrances acting as expansion chambers. This observation was of outstanding significance to the consideration of London tubes as shelter.

All previous research on blast in tunnels - and a great amount of work was done on this in the last war - had been conducted with blast entering the open end of a tunnel without side openings. This research had shown that the blast, once it had got into a tunnel, tended to travel great distances without appreciable diminution. This had, therefore, led to the general belief that the London tubes could be death traps rather than shelters.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about $\frac{1}{3}$ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

In fact A.W.R.E. carried out two further tests, with more accurate scaling of station volumes based on more detailed information from the London Transport Executive. A full report on all four tests is in preparation.

These later tests showed that the pressure in station tunnels was only about 1/6th of the ground-level pressure, but that the reduction was not so great in the smaller-diameter train tunnels.

At this stage the Advisory Group were reasonably satisfied that this problem - of blast entry from stations - had been solved. But the other major question of blast entry direct from the crater remained in doubt, on account of the very small scale of the tests to date. Therefore, when the opportunity arose of testing at a really large scale at Suffield, Canada, it was naturally accepted.

Large-Scale Field Test (1/40) at Suffield, Alberta

The test is fully described in an A.W.R.E. report[6]. The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at 1/40th scale, that had already been tested at 1/117 scale.

Blast Entry from Stations

There was remarkable agreement with the 1/117th scale trials: "maximum overpressure in the train tunnels was of the order of $\frac{1}{3}$rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about 1/6th those in the corresponding incident blast .... ". In comparing the results at the two scales it was noted that the pressures in the train tunnels (between stations) was higher at Suffield than at the smaller scale; this may, the report suggests, have been due to some blast entry from the crater at Suffield.

Blast Entry from the Crater

There may - as has just been noted - have been some entry of blast at the crater. But the all-important fact is that it was nowhere enough to bring the pressure in the tunnel up to more than a $\frac{1}{3}$rd of the free-air pressure (see fig. 30 reproduced, and attached to this note.) From this, and from a detailed study of tunnel rings ejected by the explosion over a wide area, it can be concluded that the instantaneous crushing of the tube near the crater sealed it against the entry of any significant blast pressure.

References

(1) Advisory Group on Structural Research for Civil Defence

Note by Chairman on the Structural Research Programme for Shelters. SAB/SG(57)6. (Restricted)

(2) Notes of Meeting on 15th May 1957. SAB/SG(57)2nd Minutes (Confidential)

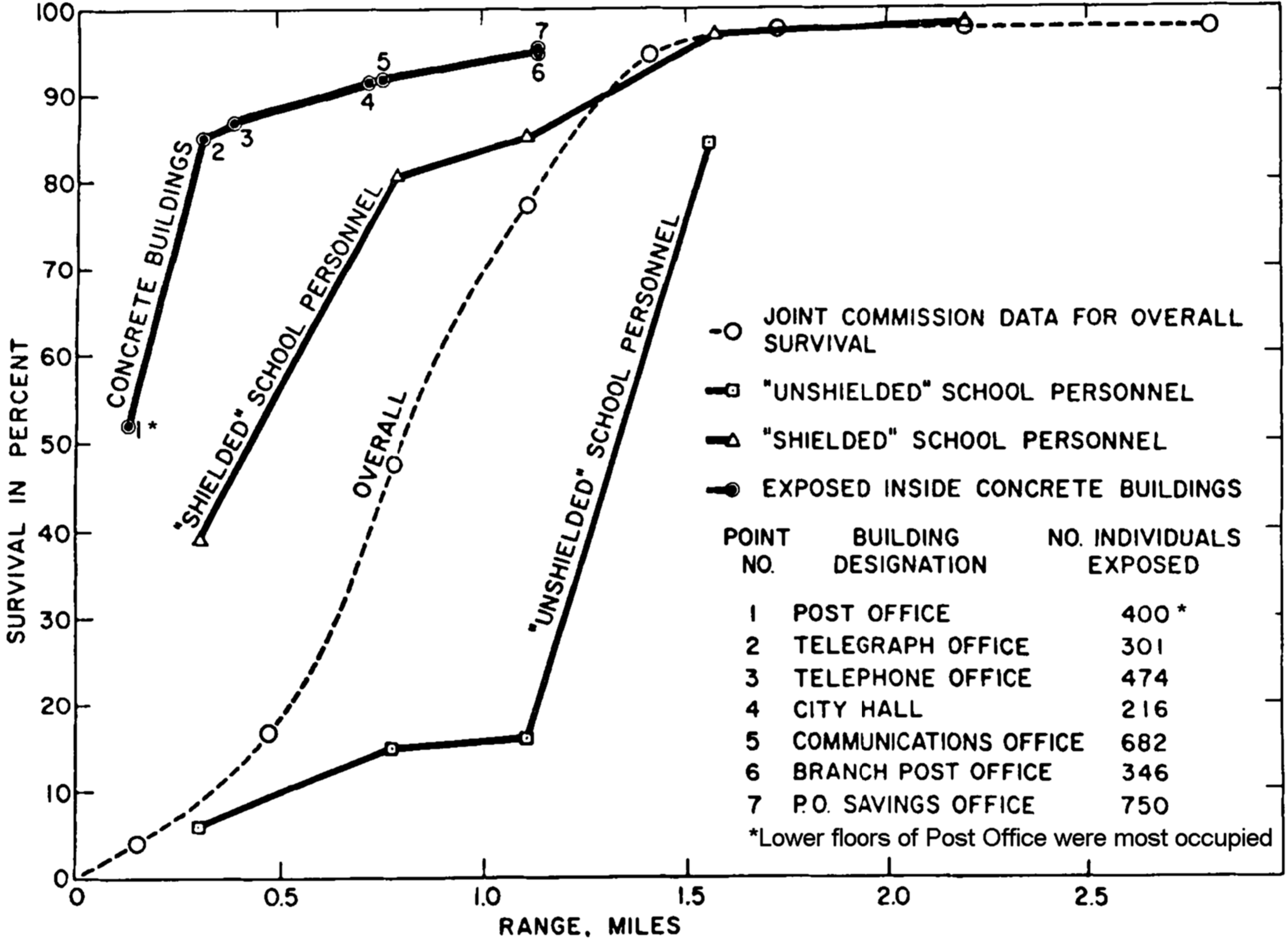
(3) The Entry of Air Blast from Craters into Tunnels. A.W.R.E. Report E1/59 (Official Use Only)

(4) The Effect of Tunnel Blockage on Shock Waves .... SAB/SG(58)6 (Confidential)

(5) Model Experiments on the Entry of Blast into the London Underground System, Interim Report on Rounds 1 and 2. SAB/SG(59)4 (Confidential)

(6) 1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62. (Official Use Only.)

Aldwych Underground tube station as Blitz shelter, 8 October 1940



Percentage of survivors as a function of range from Ground Zero (Hiroshima). (Ref. Joint Commission Report, Vol. VI, Document NP-3041.)

The Effects of Atomic Weapons

PREPARED FOR AND IN COOPERATION WITH THE U. S. DEPARTMENT OF DEFENSE AND THE U. S. ATOMIC ENERGY COMMISSION

Under the direction of the

LOS ALAMOS SCIENTIFIC LABORATORY

LOS ALAMOS, NEW MEXICO

Revised September 1950

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PRINCIPLES OF AN ATOMIC EXPLOSION

A. INTRODUCTION

Characteristics of an Atomic Explosion

1.1 The atomic bomb is a new weapon of great destructive power. It resembles bombs of the more conventional type in so far as its explosive effect is the result of the very rapid liberation of a large quantity of energy in a relatively small space. But it differs from other bombs in three important respects: first, the amount of energy released by an atomic bomb is a thousand or more times as great as that produced by the most powerful TNT bombs; second, the explosion of the bomb is accompanied by highly-penetrating, and deleterious, invisible rays, in addition to intense heat and light; and third, the substances which remain after the explosion are radioactive, emitting radiations capable of producing harmful consequences in living organisms. It is on account of these differences that the effects of the atomic bomb require special consideration.

1.2 A knowledge and understanding of the mechanical and radiation phenomena associated with an atomic explosion are of vital importance. The information may be utilized, on the one hand, by architects and engineers in the design of structures; while on the other hand, those responsible for civil defense, including treatment of the injured, can make preparations to deal with the emergencies that may arise from an atomic explosion.

1.3 During World War II many large cities in England, Germany, and Japan were subjected to terrific attacks by high-explosive and incendiary bombs. Yet, when proper steps had been taken for the protection of the civilian population and for the restoration of services after the bombing, there was little, if any, evidence of panic. It is the purpose of this book to state the facts concerning the atomic bomb, and to make an objective, scientific analysis of these facts. It is hoped that as a result, although it may not be feasible completely to allay fear, it will at least be possible to avoid panic.

---

[1] Material contributed by G. Gamow, S. Glasstone, J. O. Hirschfelder.

8.90 Apart from the effect of the base surge, radioactive contamination will result from the rain produced by the fall-out. There has been some difference of opinion concerning the relative contributions of the base surge and the fall-out to the total radiation dosage. The question is of practical significance, since some protection of personnel from ordinary rainfall, as from the fall-out, is possible in the open. But since the base surge is a cloud which moves laterally, protection from its radiation is not so simple. There is no doubt that at Bikini, the base surge was very significant, and it appears that, in general, both base surge and fall-out will contribute to the radiation dosage, the relative amounts depending on the depth of burst, depth of water, and other conditions.

8.91 From measurements made at the time of the Bikini "Baker" test, it has been possible to draw some general conclusions with regard to the integrated or total radiation dosage received at various distances from surface zero. Actually, about 90 percent of this dosage was attained within 30 minutes of the explosion. The results are represented in the form of radiation dosage contours in Figs. 8.91a,

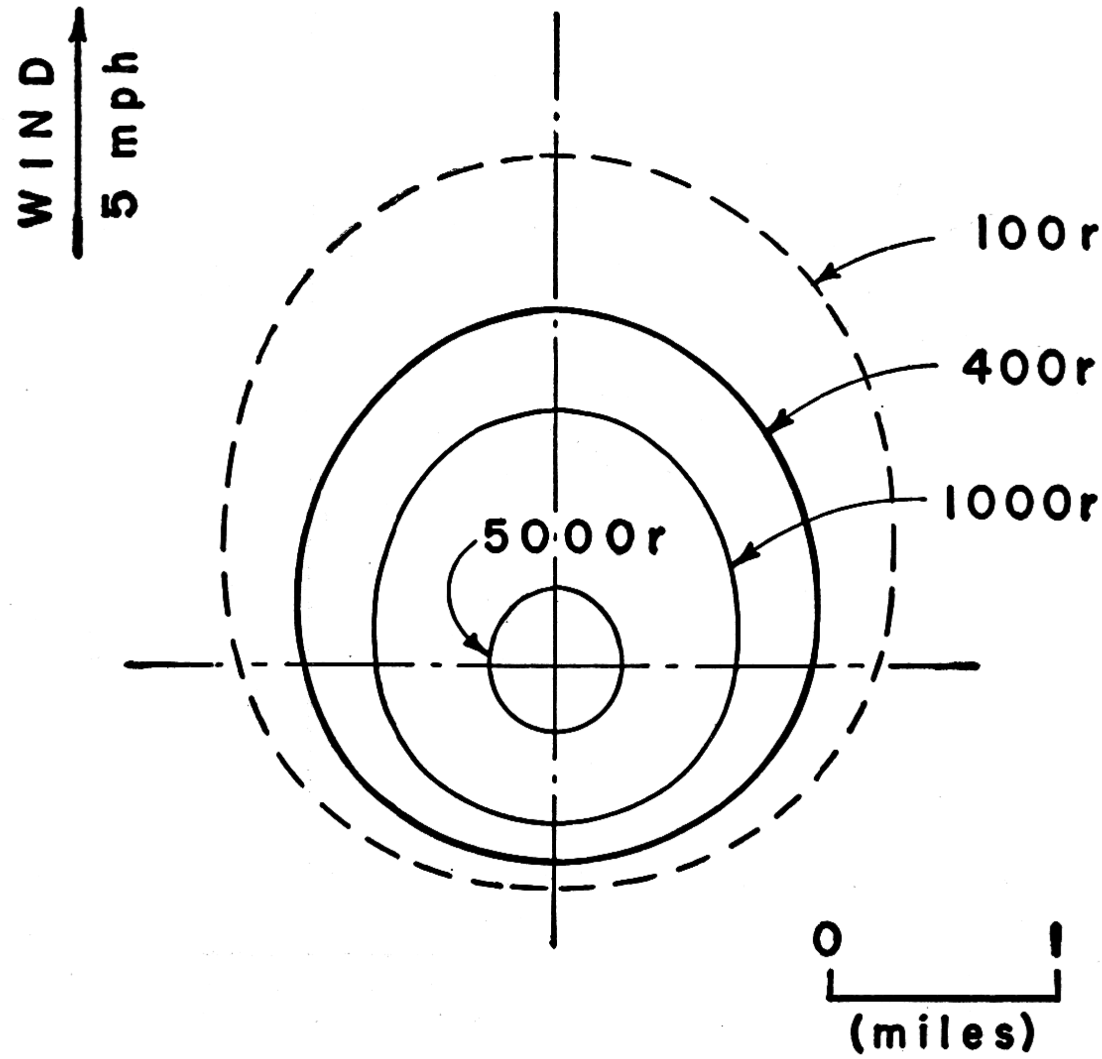

Figure 8.91a. Contours for various integrated radiation dosages due to base surge from underwater burst.

b, and c. The dosage due to the base surge mist as it passes over and through an area is shown in Fig. 8.91a. The distortion from symmetry is due to the fact that a wind of about 5 miles per hour was blowing at and near the surface of the lagoon at the time of the detonation. This results, of course, in the radioactive contamination extending much further downwind than in the upwind direction.[19]

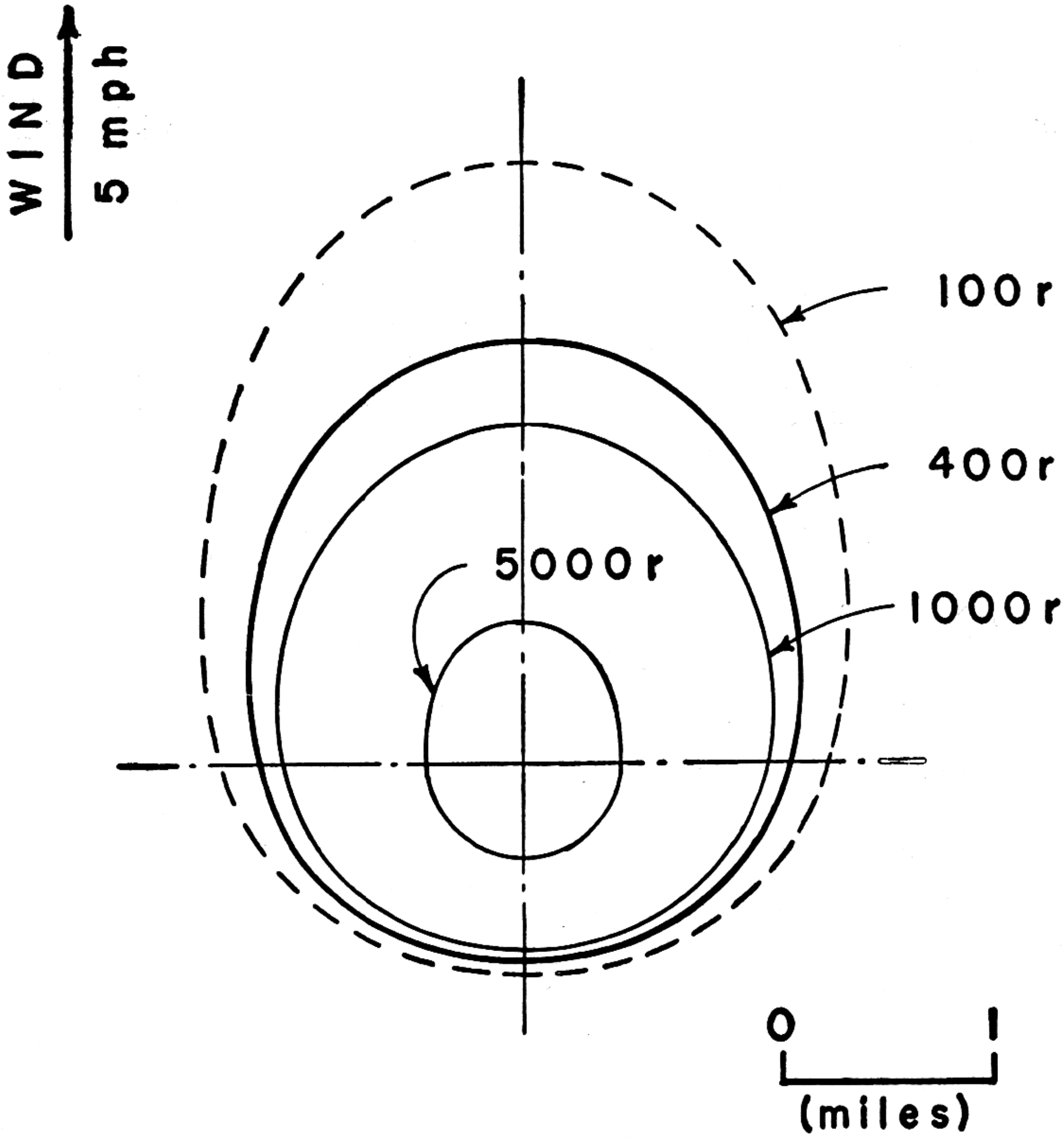

Figure 8.91b. Contours for various integrated radiation dosages due to contamination from underwater burst.

8.92 The integrated dosage contours resulting from contamination due to rain from both the base surge and the fall-out from the atomic cloud, are given in Fig. 8.91b, while Fig. 8.91c indicates the contours for total dosage, i. e., the sum of the base surge and contamination dosages. It is probable that the data in Fig. 8.91b, and hence also in Fig. 8.91c, represent an underestimate, because a proportion of the contaminated water falling as rain ran off the decks of

[19] For the effect of wind on the area, etc., of the base surge, see § 4.79.

the ships and back into the lagoon, so that its activity was not included in the measured dosage.

8.93 It may be mentioned that the radioactive mist of the base surge is most hazardous within the first few minutes of its formation.

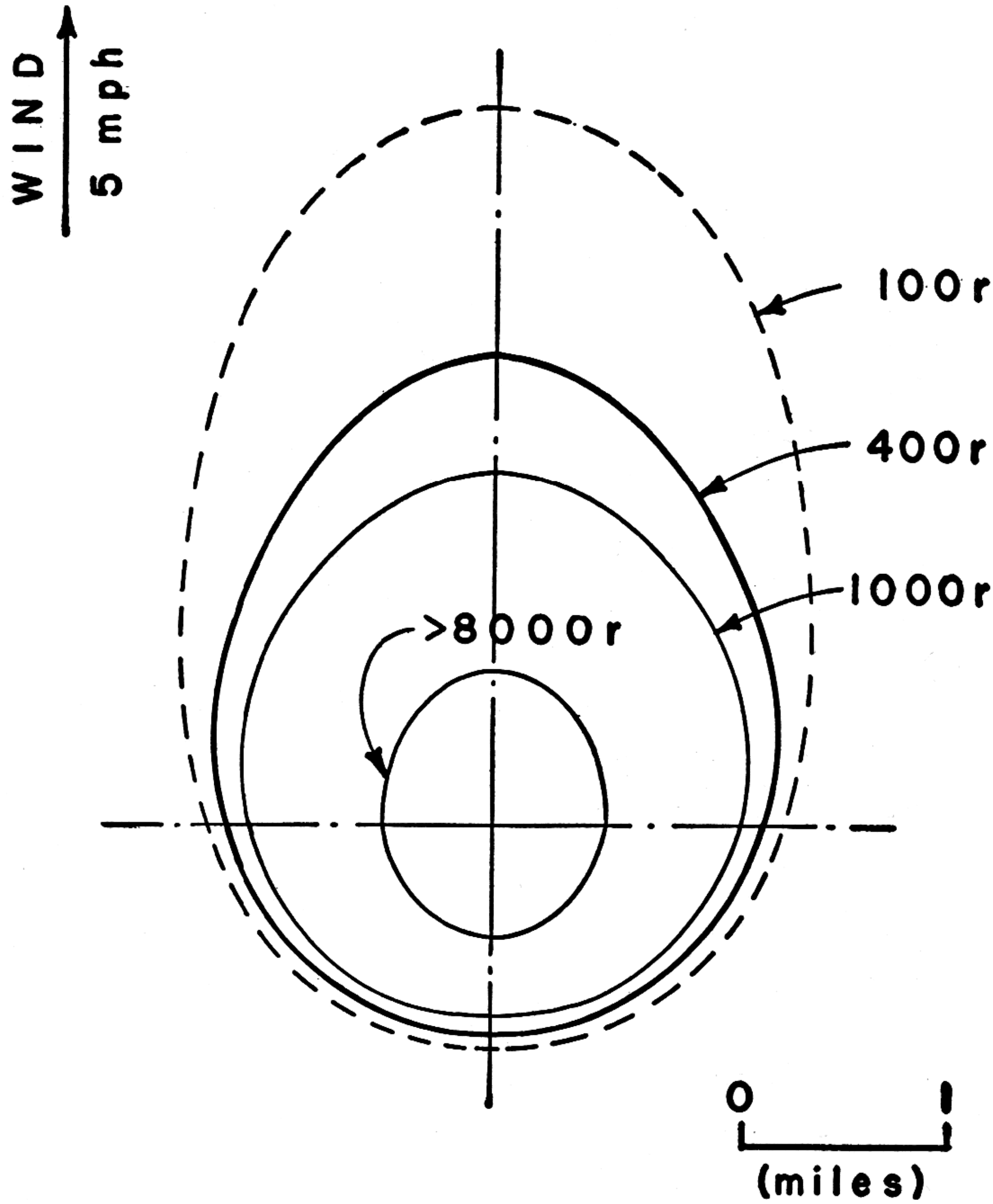

Figure 8.91c. Contours for total dosage due to base surge and contamination from underwater burst.

Its activity decreases rapidly in the course of a short time due to the operation of three factors, namely, dilution by increase of volume as a result of mixing with air, raining out of the active material as the droplets increase in size, and natural radioactive decay. Calculations which probably give a correct order of magnitude, at least, indicate that the dosage rate within the base surge decreases by a factor of about 400 in the interval between 1 and 4 minutes after the

underwater burst. This rapid decrease indicates the advantage of protection from the base surge mist during the 3 or 4 minutes immediately following an atomic explosion. At Bikini, contamination of the interior of the ships, due to the base surge, was minimized by closing down the hatches and stopping the ventilating systems. Attention to this point, especially in the early stages, would obviously prove well worth while.

Radioactivity of Water

8.94 It was recorded earlier that in an underwater burst of an atomic bomb most of the radioactivity of the fission products ultimately appears in the water. Because of the large volume in which these substances are dispersed, the activity in the water is not as high as might be feared, except close to the explosion center and within a short time of the burst. As a result of diffusion of the active material, mixing with water from outside the contaminated area, and natural decay of the radioactivity, the dosage decreases with fair rapidity in a short time. In Table 8.94 are given the area and mean

Table 8.94

DIMENSIONS AND MAXIMUM DOSAGE RATE OF CONTAMINATED WATER IN BIKINI LAGOON

Time after explosion (hours)	*Contaminated area (square miles)*	*Mean diameter (miles)*	*Maximum dosage rate (r per day)*
4	16. 6	4. 6	75
38	18. 4	4. 8	10
62	48. 6	7. 9	5
86	61. 8	8. 9	1
100	70. 6	9. 5	. 6
130	107	11. 7	. 2
200	160	14. 3	. 01

diameter of the contaminated portion of the lagoon after the Bikini "Baker" test, together with maximum observed dosage rates at various times after the burst.

8.95. It is evident that, although a ship would not wish to remain in the contaminated area for any length of time soon after the explosion, passage across the water would not be a great hazard. It is to be understood, of course, that condensers and evaporators would have to be closed down while the ship is in contaminated waters. Further, because of the decrease in activity with time, it seems unlikely that an underwater burst of an atomic bomb would prevent operation of a harbor for any length of time, at least as far as contamination of the water is concerned. However, it should be borne in mind that the

results in Table 8.94, although probably fairly representative, would be affected by the geophysical conditions of the harbor.

8.96 Another factor which contributed to the loss in activity of the water at Bikini was settling of the fission products to the bottom of the lagoon. To judge from samples of bottom material collected 7 and 16 days after the explosion, a considerable proportion of the active material must have been ultimately removed in this manner. The results indicate that the major deposition had occurred within a week and that it covered an area of over 60 square miles. On the assumption that the fission products had penetrated to a depth of 1 foot, it can be estimated that the total mass of the bottom material, in which the radioactivity was distributed, was about 1.4×10^8 tons. Consequently, even though the total initial activity of the fission products was high, about 2×10^6 curies measured a week after the explosion, its wide distribution at the bottom of the lagoon would mean that it did not represent a great hazard to marine life. Observations made several months after the explosion indicated, too, that there was no tendency for the contaminated material to spread.

8.97 It is of interest in this connection to calculate the amount of radiation due to the radioactive isotope of potassium, mass number 40, in sea water. This isotope is present to the extent of 0.012 percent in all forms of potassium, regardless of its source. It emits a beta particle, with a maximum energy of 1.3 Mev, and a gamma photon of 1.5-Mev energy. Because of its long half life, about 1.5×10^9 years, the activity is normally of little significance, although it makes an appreciable contribution to the total background radioactivity of the body (§ 8.49). Since sea water contains 0.4 gram of potassium per liter, the total weight of radiopotassium 40 in the Bikini lagoon is estimated to be 1.4×10^9 grams or 2.1×10^{31} atoms. From the known half life it can be calculated that there will be a total of about 4×10^{14} disintegrations per second, which is equivalent to 10^4 curies of activity due to the potassium 40 alone. In other words, the normal background activity of Bikini lagoon, before the atomic bomb explosion, was at least 10^4 curies. This is not very different from the fission product activity collected at the bottom about 18 months after the detonation.

8.98. There is a possibility that after an underwater burst of an atomic bomb, the radioactivity might be spread over a large area due to the action of marine life. It is well known that land plants absorb and so concentrate mineral elements from the soil and that these are further concentrated in animals feeding on the plants. Similar circumstances arise in water environments; the simple plants, i. e.,

phytoplankton and algae, absorb the nutritive salts from the water, and they are then accumulated in the larger aquatic forms, e. g., fish, which directly or indirectly consume the simple plants.

8.99 In water containing radioactive materials, the latter are concentrated by the fish in the same manner and for the same length of time as are the stable forms of the corresponding elements. If the fish die, the radioactive isotopes are not lost, but they return to the water, as do the stable isotopes, to take part once again in the life cycle. Because of the landlocked nature of the Bikini lagoon, there is evidently little or no outward migration of the larger aquatic organisms so that, as mentioned above, there is no appreciable tendency for the radioactivity to spread. However, due to the behavior of the anadromous migratory fishes, e. g., salmon, shad, etc., which feed in the sea and then migrate upstream to die, or of birds that concentrate the minerals of the sea in guano, there might be some distribution of radioactivity in other cases following an underwater atomic explosion. The extent of such dispersion and its effects would depend greatly on circumstances and appears difficult to estimate.

Radioactive Contamination of Land Areas

8.100 The underwater burst at Bikini took place far enough from shore to prevent any appreciable contamination of land areas. Some radioactive rain fell at large distances from the explosion center (§ 2.36), but the activity was not serious. The possibility must be considered, however, of an underwater atomic explosion so near to the shore that significant amounts of the fall-out and the base surge will reach the adjacent land areas, and possibly affect dock facilities, warehouses, etc. As indicated earlier, because some of the radioactively contaminated water ran off the ships at Bikini, the values in Figs. 8.91b and 8.91c may represent an underestimate if applied to the shore. However, there may be compensating factors in the deposition of active material on the roofs or protruding portions of buildings, and also because of the shielding effects of various structures.

8.101 A rough attempt to assess the contamination, in terms of radiation dosage rates, of adjacent land areas from the underwater burst of a nominal atomic bomb, at 1 hour after the explosion is made in Fig. 8.101. The results are based on the assumption that the activity is due to fission products with a mean gamma-ray energy of 0.7 Mev (§ 8.11). Four contour lines are shown, representing radiation dosage rates of 400, 50, 10, and almost zero roentgens per hour, respectively. In the region outside the last contour line, the danger

12.59 If a person is in the open when the sudden illumination is apparent, then the best plan is instantaneously to drop to the ground, while curling up so as to shade the bare arms and hands, neck, and face with the clothed body. Although this will not protect against gamma rays, it may help in reducing flash burns (§ 6.53). This is important since disabling burns can be suffered well beyond the lethal range for gamma rays (Fig. 12.13). The curled-up position should be held for at least 10 seconds; the immediate danger is then over, and it is permissible to stand up and look around to see what action appears advisable.

12.60 If in the street, and some sort of protection, such as a doorway, a corner or a tree is within a step or two, then shelter may be taken there with the back to the light, and in a crouched position to provide maximum protection, as described above. No attempt should be made to reach a shelter if it is several steps off; the best plan then is to crouch on the ground, as if completely in the open. After 10 seconds, at least, a standing position may be resumed, but it is strongly advisable to press the body tightly against the side of a building to avoid breaking glass or falling missiles, as far as possible.

12.61 A person who is inside a building or home when a sudden atomic bomb attack occurs should drop to the floor, with the back to the window, or crawl behind or beneath a table, desk, counter, etc.; this will also provide a shield against splintered glass due to the blast wave. The latter may reach the building some time after the danger from radiation has passed, and so windows should be avoided for about a minute, since the shock wave continues for some time after the explosion. The safest places inside a building are the interior partitions, and it is desirable to keep as close to these as possible.

D. PROTECTION FROM RESIDUAL RADIATIONS

Introduction

12.62 As stated earlier, protection of large numbers of people from the effects of the residual nuclear radiations, that might follow the explosion of an atomic bomb, represents an entirely new problem concerning which there has been no previous experience. After the attacks on Japan the fission products were so widely dispersed as not to be an appreciable danger; at least, there is no evidence that such a hazard existed. In special circumstances, however, for example, an underwater burst close to the shore or an underground or surface burst, or in the event of the use of radiological warfare weapons, pre-

cautions would have to be taken against the residual radiations. In the present section an outline will be given of the general lines of procedure that might be followed for radiological defense; in view of the lack of experience, these may be regarded as tentative and subject to improvement.

12.63 Since the possibility of combating radioactive contamination is bound up with the extent of the associated physical damage, it is desirable to make a rough classification of the possible combinations that might arise. Three general types may be distinguished:

(*a*) *Heavy Physical Damage and Heavy Contamination.*—Such a condition might be due to a combination of an air-burst atomic bomb followed, or accompanied, by the use of a radiological weapon. In view of the wasteful nature of such action, it may be regarded as not too probable, although it cannot be ignored. An underwater burst in a harbor of a large city, close to the shore, might cause both heavy damage and contamination over a limited area. In this event, radiological safety measures might be delayed by the necessity of clearing away debris, establishing communications, etc.

(*b*) *Heavy Physical Damage and Light Contamination.*—This would arise from an atomic explosion of the type experienced at Hiroshima and Nagasaki. The problem of protection against radioactivity would not be serious in this case. It would be necessary for monitoring teams to follow the radioactive cloud downwind in case there were a marked fall-out in any particular area. It is of almost equal importance to know definitely that there is no hazard.

(*c*) *Moderate or Little Physical Damage and Moderate to Heavy Contamination.*—Such circumstances could arise from a radiological warfare attack, from dry or wet fall-out, from base surge on a ship or on shore at some distance from an underwater explosion, or from an ineffective ("fizzle") explosion of an atomic bomb. The radioactive protection would be of the greatest significance, and to meet these conditions the radiological defense system must be especially prepared.

Stages of Disaster

12.64 In considering the practical problems of a radiological hazard it may be supposed that there will be three stages, the duration and

severity of which will depend on circumstances described above. These are as follows:

(*a*) *Complete Disorganization.*—In the event of heavy and widespread physical damage, it may be presumed that roads will be blocked for some distance from the explosion, and that all normal communication systems will be out of commission. Emergency transportation and communication, except perhaps for self-contained radio equipment, will not be immediately in effect.

(*b*) *Emergency Control Stage.*—This phase will begin as soon as margin roads have been cleared, and transportation and communication has been reestablished, at least on an emergency scale, so that information can be transmitted to a control room. In the case of moderate physical disaster (§ 12.63 (*c*)), the emergency control phase would start immediately, and might last a week or more.

(*c*) *Recovery Stage.*—The final phase would be reached when most people were out of immediate danger of injury, and there is time to start more thorough decontamination operations where necessary (Chapter X).

12.65 In the emergency control phase, an important factor in the operation of radiological defense is the rapid gathering of data regarding contamination. The radiations which may be encountered are gamma rays and beta particles from fission products, neutron-induced activity or other radioactive material, and alpha particles from plutonium or uranium. Of these, the gamma radiation can be measured most readily; this is perhaps the greatest immediate hazard because of its considerable penetrating power. Beta particles as such are not a serious menace unless the source enters the system or remains on the skin for some time.

12.66 Monitoring of suspected contaminated areas for gamma radiation should be carried out at the earliest possible moment after an atomic explosion in which such contamination is likely to have been produced. Initially, this might even be done by means of low-flying aircraft; from the gamma radiation dosage measured at a known height above the ground it will be possible to obtain an approximate indication of the area and intensity of contamination (see Fig. 8.35). However, ground monitoring for gamma radiation, with portable instruments, will be necessary at the first opportunity. The monitoring for beta radiation will, in general, be an auxiliary measurement, made in the later stages after the immediate emergency has passed.

A PENGUIN SPECIAL

THE PSYCHOLOGY OF FEAR AND COURAGE

BY

EDWARD GLOVER

(Published for Blitz air raids in 1940)

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HARMONDSWORTH MIDDLESEX ENGLAND

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Real knowledge, for example, is one of the best antidotes to unreal fear. *Useful action* is also an excellent preventive, and *vigorous preparation to meet real danger* will enormously reduce unreal fear. The strength of a common purpose will do the rest. Knowledge, a common purpose, and preparedness for action. These are the remedies for faintness of heart in the face of danger.

22

Now as to preparation. You may recall that when Napoleon was asked how he was always able to give an instant decision in a crisis, he replied: "Because I constantly prepare every detail in advance." Here is a discipline you can readily cultivate. Always make a point of knowing beforehand *exactly* what you are going to do in an air raid; whether you find yourself in house, street, train, bus or shelter. Have it word perfect.

23

A stray crowd packed into a cinema is likely to panic at the cry of "Fire." There are no common bonds between the people concerned; and there are no leaders. Each one is for himself.

34

Already we have the advantage that we are fighting not only for our lives and homes but for the immemorial cause of human liberty. But that is not enough. Provided we are united with our leaders in a common effort, real danger will never sap our morale. The greatest danger to our morale is unreal fear.

36

However hackneyed the adage: " United we stand, divided we fall," it is still the most profound of psychological truths.

119

Take, for example, the ideas of communism and fascism, which obviously overstep the barriers of nationalism. A moment's reflection will show that these ideas do not unite nations. On the contrary, unless the peoples concerned are deprived of freedom of speech, thought and political power, they cause acute dissension rather than unity. They disintegrate.

121

one of the greatest flaws of the Nazi political philosophy is its stupendous over-estimation of the significance of the State. Compared with the organisation of an individual, the State is an almost amorphous mass.

122

For if you want children's minds to develop, you must not poison them with important illusions. You must let their minds be free to observe and judge.

126

Euripides:

" What then is Wisdom? What of man's endeavour?

. . . .

To stand from Fear set free, to breathe and wait,
To hold a hand uplifted over Hate.
And shall not Loveliness be loved for ever?"*

* *Bacchae*. (Gilbert Murray's translation.)

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RESTRICTED
Security Information

RADIOLOGICAL DEFENSE

Vol. II

The Principles of Military Defense against Atomic Weapons

Armed Forces Special Weapons Project

November 1951

RESTRICTED
Security Information

FOREWORD

While the atomic bomb is admittedly a weapon of great power, it is not to be regarded as an absolute weapon—that is to say, it is not a weapon against which there is no defense. Throughout history, the introduction of every new weapon has been followed by the development of defensive measures which have lessened its effectiveness. However, the development of suitable defensive measures against atomic weapons requires an understanding of the characteristics and effects of these weapons under various circumstances. Unfortunately, many misleading and exaggerated reports of the consequences of such weapons have received wide publicity, and these have made more difficult the task of those responsible for the planning of atomic defense.

The original drafts of the material for this volume were prepared at the Naval Radiological Defense Laboratory, San Francisco, partly from contributions of its staff and partly from material supplied by other representatives of the Armed Services who collaborated in this work. It is regretted that it is not feasible to list the names of the many individuals, both uniformed and civilian, who have assisted in the assembly and review of the contents of this book. Their efforts are sincerely appreciated. It is also desired to acknowledge the valuable assistance rendered by the Atomic Energy Commission in making available Dr. Samuel Glasstone, who acted as Executive Editor in the final rewriting and integration of the manuscript.

HERBERT B. LOPER
Brigadier General, USA
Chief, Armed Forces Special Weapons Project

1.05. The three planes, which appeared over the city so soon after an "all clear" had been given, were not taken seriously. It was thought that they were observation planes, and even if they had been bombers, their bomb load was evidently not considered sufficient to merit a further disruption of the city's daily routine. From the standpoint of defense against the atomic bomb, the important lesson is that no enemy plane, whether it comes singly or in a group, can be disregarded. Had the inhabitants of Hiroshima remained in their shelters, the number of casualties would have been greatly decreased.

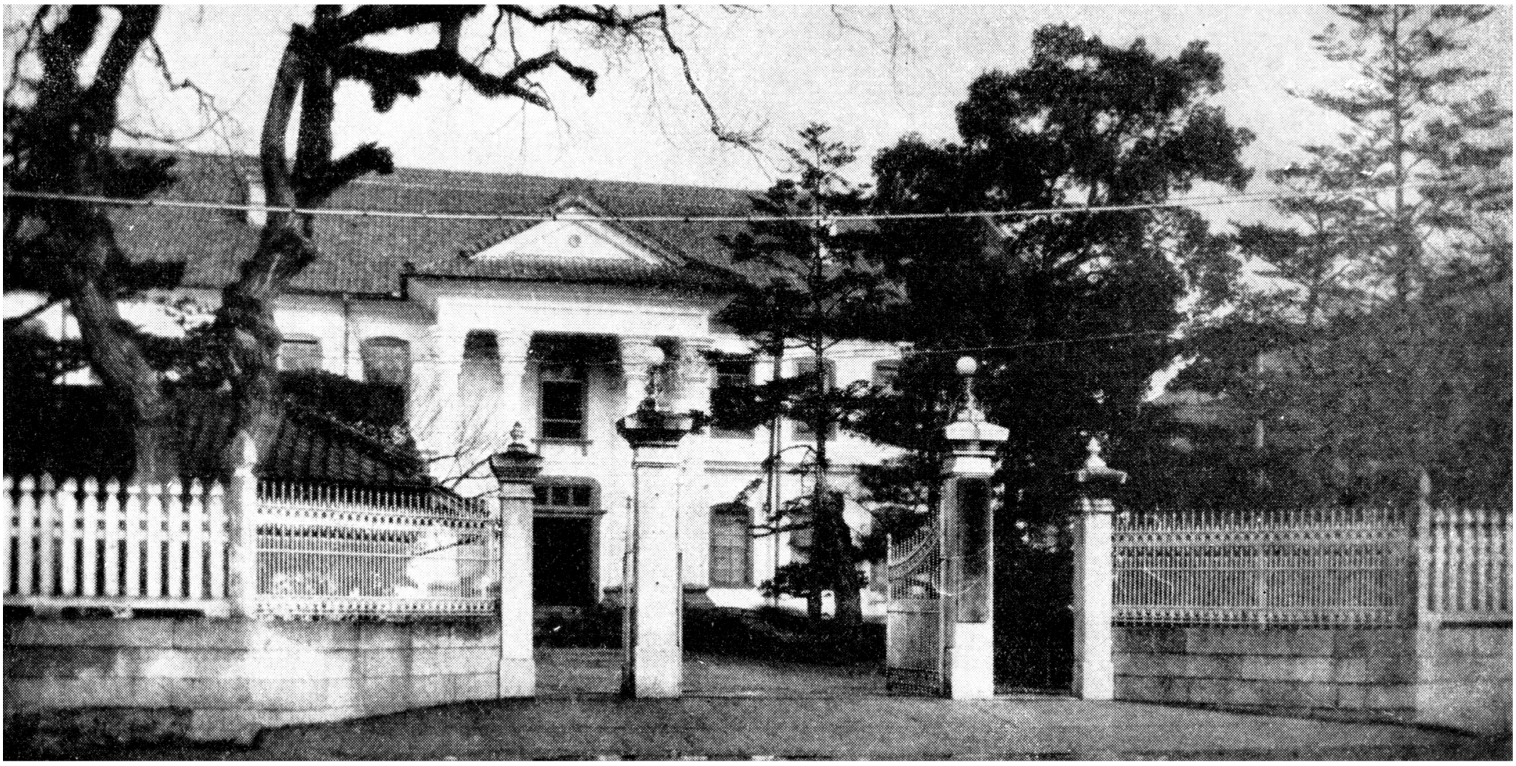

Figure 1.02a. The Hiroshima Prefecture (approximately 1,000 yards from ground zero) before the atomic explosion.

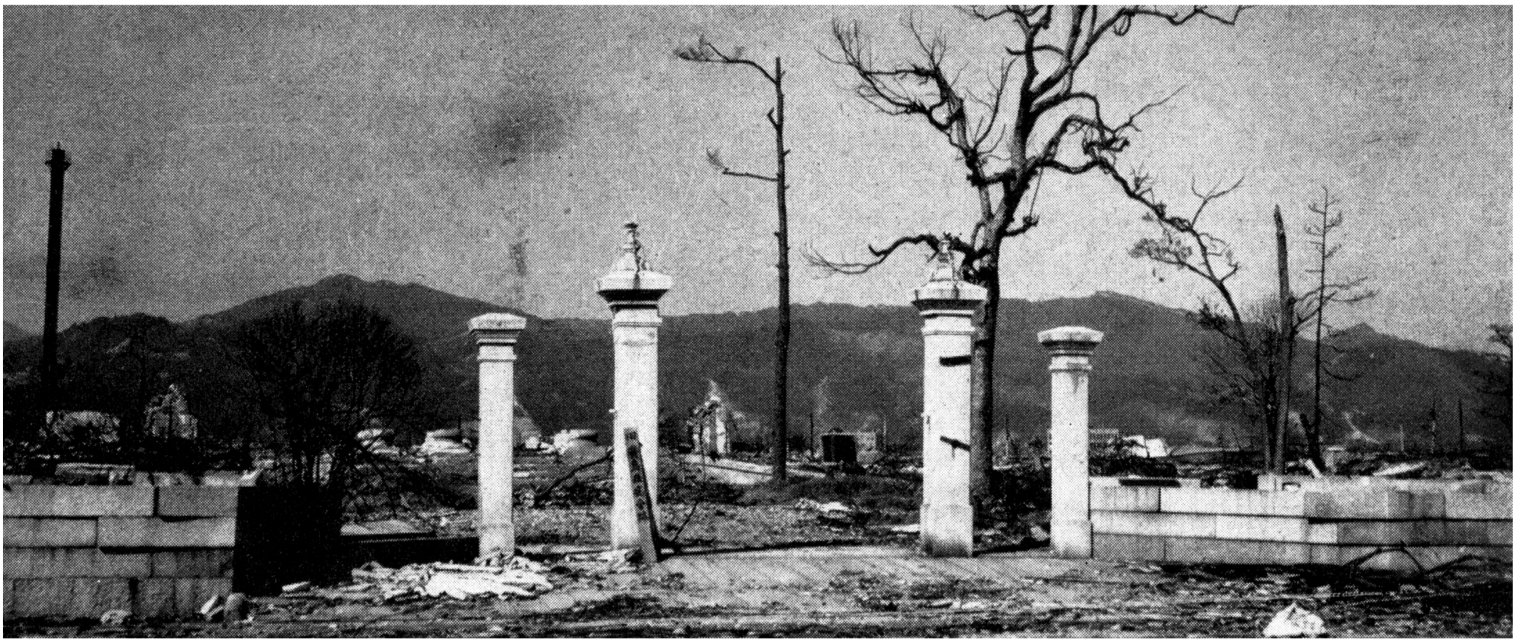

Figure 1.02b. The Hiroshima Prefecture after the atomic explosion.

1.09. Since a large number of the inhabitants as well as considerable residential areas of the city survived the explosion, rescue efforts at Nagasaki were soon organized. The water supply was partially restored by the second day after the dropping of the bomb, and some electric power was available at the end of the same day. On the following day a few streetcars and railway trains were running again.

Comparison of Atomic and Conventional Bombs

	Hiroshima Atomic Bomb	Nagasaki Atomic Bomb	Tokyo 1,667 tons Incendiary and TNT	Average of 93 Attacks 1,129 tons Incendiary and TNT per attack
Square miles destroyed	4.7	1.8	15.8	1.8

Primary and Secondary Fires

6.31. Fires accompanying an atomic explosion may be distinguished as primary or secondary, according to their origin. Primary fires are those caused directly by the thermal radiation igniting paper, thin cloth, rags, wood, dry vegetation, etc. Secondary fires are due to other causes, for which the blast is mainly responsible, such as upset stoves and furnaces, broken gas and other fuel lines, electrical short circuits, and so on. The evidence from Hiroshima and Nagasaki indicated that the great majority of fires were secondary in nature.

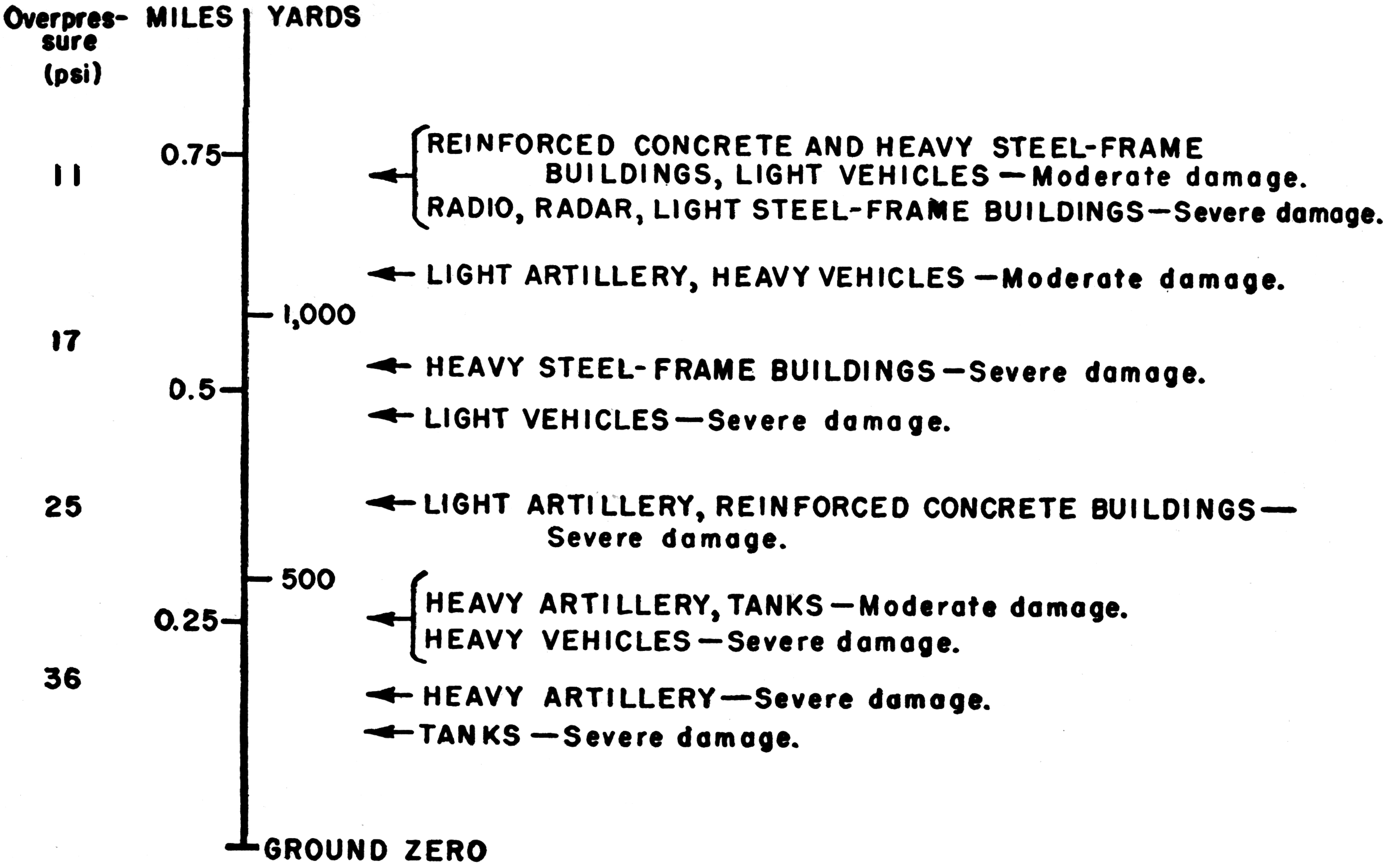

Table 6.59. nominal atomic bomb at 2,000 feet altitude.

YARDS	AIR BURST	UNDERWATER BURST
1,500	LIMIT OF IMPORTANT DAMAGE TO SHIPS.	AIRCRAFT CARRIERS, BATTLESHIPS, CRUISERS, DESTROYERS—Light damage.
	BOILERS—Moderate damage.	
1,000	ANTENNAS, DIRECTORS, LIGHT EQUIPMENT, BOILERS—Severe damage.	AIRCRAFT CARRIERS, BATTLESHIPS, CRUISERS, DESTROYERS—Moderate damage.
	DESTROYERS—Moderate damage.	AIRCRAFT CARRIERS, BATTLESHIPS, CRUISERS, DESTROYERS—Severe damage.
	AIRCRAFT CARRIERS, CRUISERS, TRANSPORTS—Moderate damage.	SUBMERGED SUBMARINE—Sunk.
	BATTLESHIPS—Moderate damage. DESTROYERS—Severe damage.	
	ORDNANCE—Severe damage.	
500		
	AIRCRAFT CARRIERS, LIGHT CRUISERS, TRANSPORTS—Severe damage	
	HEAVY CRUISERS—Severe damage.	
	BATTLESHIPS—Severe damage.	
SURFACE ZERO		

Table 6.92. Comparison of damage ranges to ships, due to air burst at 2,000 feet altitude and shallow underwater burst of a nominal atomic bomb.

Figure 10.37. Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

Figure 12.96. Rough decontamination of the NEW YORK, after Test Baker at Bikini, by hosing down with sea water from a Navy rescue tug.

12.99. Following an underwater burst the base surge will constitute a possible hazard. However, if the interior of the ship is water-tight and the ventilation system is shut down completely, the entry of the base surge can be prevented. Since about a minute will elapse before the base surge overtakes a moderately undamaged ship, there should be time for personnel to take appropriate cover and for the ship to be secured by closing all ventilation intakes, doors, and hatches. This is an operation which can be planned and practiced in advance, so that it can be performed as quickly as possible.

12.100. It was stated in paragraph 11.38 that if topside structures are wetted with sea water before an atomic attack, contaminated particles can subsequently be removed much more readily. It is expected that, where practicable, future ship design will make provision for a "water curtain" for flushing weather surfaces prior to an attack, and for subsequent possible decontamination. Generally, however, the ship's fire hoses may be used to drench all exposed topside surfaces. Trial experiments will indicate how quickly the wetting-down operation can be performed.

AIR WAR AND EMOTIONAL STRESS

Psychological Studies of Bombing and Civilian Defense

Irving L. Janis

The RAND Corporation

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1951

CHAPTER 2
EMOTIONAL IMPACT OF THE A-BOMB

UNPREPAREDNESS OF THE POPULATION

At both Hiroshima and Nagasaki, disaster struck without warning. Whether intended so or not, an extraordinarily high degree of surprise was achieved by both A-bomb attacks. At the two target cities, prior to the bombing, there had been relatively little anxiety about the threat of heavy B-29 raids. When the planes carrying the A-bomb arrived over their targets, the population was almost completely unprepared. At the time, not even a light air raid was expected. People were caught at home, at work, out on the city streets, calmly going about their usual daily affairs.

When the first A-bomb was dropped, on August 6, 1945, very few residents of Hiroshima were inside air-raid shelters. An all-clear signal from a previous alert had sounded less than half an hour earlier and the normal routine of community life had resumed. Shortly after eight in the morning, when the explosion occurred, the working-class population was arriving at the factories and shops. Many workers were still out-of-doors en route to their jobs. The majority of school children, along with some adults from the suburbs, were also outside, hard at work building firebreaks as a defense against possible incendiary raids. Housewives, especially in middle-class families, were at home, preparing breakfast. Only a few minutes later, their flaming charcoal stoves were to create hundreds of local fires, adding to a general conflagration of such intensity that even if the assiduous labor of Hiroshima's school children had been completed, the fire storm still would have been beyond control.

At Nagasaki, three days later, the populace had heard only vague reports about the Hiroshima disaster. Here again, people were at

work in factories and offices, tending their homes, engaging in their normal daily activities. A few hours earlier a raid alert had been canceled; before the raid signal could be repeated, the bomb had already exploded. Only 400 people out of a population of close to a quarter of a million were inside the excellent tunnel shelters that could have protected some 75,000 people from severe injury or death.

It is generally recognized that the element of surprise was an important factor contributing to the unprecedented casualty rates at Hiroshima and Nagasaki. Many of those who were exposed to lethal gamma radiation, struck down by flying debris, or trapped in collapsed buildings would not have been killed if they had been warned in time to flee to the outskirts of the city or if they had been in adequate shelters. Thousands of people who were out-of-doors or standing in front of windows would have been protected from incapacitating flash burns if they had been under any sort of cover.[1]

Whether or not they suffered severe injury, those who survived the explosion were also affected by the element of surprise in quite another way. The absence of warning and the generally unprepared state of the population undoubtedly augmented the emotional effects of the disaster. "I was just utterly surprised and amazed and awed." This brief remark, by a newspaper reporter who was living in Nagasaki at the time of the disaster, epitomizes the way in which survivors described the terrifying events to which they were so suddenly exposed.

Of great importance in the predispositional set of the population is the fact that there was not a state of readiness to face danger or to cope with the harsh exigencies of a major catastrophe. The stage was well set for extreme emotional responses to dominate the action. It is against this background of psychological unpreparedness that the emotional impact resulting from the atomic disasters should be viewed.

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[1] USSBS Report, *The Effects of Atomic Bombs on Hiroshima and Nagasaki,* U.S. Government Printing Office, Washington, D.C., 1946.

Time from flash to blast = 4 sec at 1 mile:

Although exceedingly brief, this time interval was apparently sufficient for executing some forms of protective action.

A substantial proportion of the respondents in Hiroshima and Nagasaki reported having reacted immediately to the intense flash alone, as though it were a well-known danger signal, despite the fact that they were unaware of its significance at the time. A number of them said that they voluntarily ducked down or "hit the ground" as soon as the flash occurred and had already reached the prone position before the blast swept over them. A Nagasaki housewife told about being suddenly frightened by "something shining in the sky" as she was entering her home; she managed to run into her bedroom "to hide" before the blast wave reached the house and shattered all the windows. A worker in Nagasaki reported that he was out in the street waiting for a streetcar when the big "flash-like electric spark" occurred; he promptly dashed into a nearby public shelter and was inside by the time the blast wave struck. These examples indicate that the atomic flash was not merely an impressive visual stimulus but also, in some cases at least, a danger signal evoking semi-automatic overt responses. The examples culled from the interviews serve to amplify one of the incidental observations mentioned in the USSBS medical report: "Japanese claim that in some instances persons were able to shield their faces with their hands between the time the flash was seen and the time the heat wave reached them."[8]

In the instances cited so far, the prompt action proved to be of a highly adaptive character in that it minimized exposure to the secondary heat and blast waves, preventing burns and concussive blows. The interviews also indicate that this was not always the case. The opportunity to minimize the danger was sometimes missed because the individual remained fixed, staring at the place where he saw the flash, or because the prompt action proved to be wholly in-

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[7] Los Alamos Scientific Laboratory, *The Effects of Atomic Weapons*, U.S. Government Printing Office, Washington, D.C., 1950.

[8] USSBS Report, *The Effects of Atomic Bombs on Health and Medical Services in Hiroshima and Nagasaki*, U.S. Government Printing Office, Washington, D.C., 1947.

appropriate. The following is an example of the latter type of nonadaptive behavior: A young woman in Nagasaki stated that "when I saw the flash of light in the sky I thought it was an incendiary so I started running around looking for water to put it out." It was in the midst of this futile activity that the concussion wave arrived and bombarded her with flying debris.

From the above discussion, it is apparent that some of the survivors immediately perceived the flash as a danger signal. It also appears that for those who were not located near the center there was an opportunity to take protective action that could reduce injuries from the secondary heat wave and from flying glass, falling debris, and other blast effects. It is noteworthy that some survivors evidently failed to make use of this opportunity, as is to be expected when there has been no prior preparation for it.

In a later chapter on the problems of civil defense, we shall have occasion to take account of these findings, since they suggest that casualties in an A-bomb attack might be reduced if the population has been well prepared in advance to react appropriately to the flash of the explosion.

Under such conditions, rapid, uninterrupted flight would generally be the most adaptive response. In the absence of precise, detailed observations of escape behavior, one cannot make an adequate evaluation of the degree of emotional control exhibited by the survivors. To stop and to attempt to extricate others in the face of a rapidly spreading conflagration would sometimes be tantamount to futile sacrifice of one's own life. We cannot be sure, therefore, that those who fled without stopping to help others were behaving impulsively, since we cannot exclude the possibility that they may have been acting on the basis of a realistic appraisal of the danger situation. Our information is too incomplete to permit any fine judgments to be made; from what little is available, it would be unwarranted to conclude that there was a sizeable frequency of inappropriate, negligent, or asocial behavior merely because some instances of abandonment have been reported.

Although Hersey's case material offers little support for the notion that overt panic states were widely prevalent at Hiroshima, it does suggest that under certain local hazardous circumstances, when a large number of people were crowded together, there may have been outbreaks of excited, disorganized group behavior with antisocial consequences. One clear-cut instance of this kind is mentioned by Hersey:

> As Mr. Tanimoto's men worked, the frightened people in the park pressed closer and closer to the river, and finally the mob began to force some of the unfortunates who were on the very bank into the water. Among those driven into the river and drowned were Mrs. Matsumoto of the Methodist school, and her daughter.[30]

A single reference to disorganized group behavior also occurs in one of the eyewitness accounts from Nagasaki: A child who was seven years old at the time of the disaster reports that there was "almost a panic" among the adults in a neighborhood shelter when planes flew over on the night after the bombing.

> The ones near the entrance started pushing to get inside more. They shouted, "Get inside! Move back farther! Let us in, there'll

[30] Hersey, *op. cit.*

> be another flash!" They were so scared! And the ones inside yelled when they got squeezed, because their burns hurt. [Satoru Fukabori's story in *We of Nagasaki*][31]

It should be mentioned that these two incidents are the only examples of group panic or near-panic that were found after a thorough search of all published accounts of the atomic disasters. All the original USSBS interviews from Hiroshima and Nagasaki were also examined. No indications that would suggest the occurrence of mass panic behavior were found in those interviews. A sizeable proportion of the A-bombed survivors do mention that they ran away from the burning city after the explosion, but, in the sparse accounts of themselves and of the people whom they saw, there are no references to excited, uncontrolled behavior that could be characterized as overt "panic."

In only a handful of cases, out of more than a hundred interviewed, is there any allusion to distraught or impulsive behavior that had occurred at least momentarily. The four most extreme examples have already been quoted under "Fear and Terror Reactions," page 21. To these, only a few more could be added, all of which involve only momentary impulsive actions that were immediately brought under control. For example, one woman said that she had been so frightened by the blast that she had already run out of her destroyed house before realizing that her children were left behind, whereupon she immediately returned to the ruins and rescued them.

In contrast to the high percentage of respondents who reported having experienced feelings of fear, less than 10 per cent referred to any action carried out "without knowing what I was doing" or to any other kind of behavior that might remotely imply temporarily disorganized activity.

Obviously, the above negative evidence with respect to panic behavior cannot be taken at face value. There is no way of knowing to what extent the respondents were distorting, suppressing, or repressing their memories of the actual events of the disaster. Since no direct questions were asked about overt actions, some of the

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[31] Nagai, *op. cit.*

number of psychiatric patients admitted to hospitals and clinics, nor was there any increase in the incidence of suicides or alcoholic intoxication. For most indicators of mental disorder, the statistics show a decrease rather than an increase. For example, cases of attempted suicide among women (recorded by the police in England and Wales) decreased by 32 per cent during the year of the air blitz (1941), as compared with the prewar rate. Figures on juvenile delinquency, on the other hand, registered a rise during the war years, but, according to Titmuss, these data are not a suitable index of either juvenile or adult neurosis.

The findings cited by the various British writers are based on material obtained from a large number of psychiatrists and medical psychologists, including observers with widely different clinical and theoretical approaches to psychiatric problems. Their methods of investigation ranged from brief psychiatric examinations for purposes of large-scale statistical tabulation to intensive case studies of small groups of patients. Despite the diversity of diagnostic criteria used, there is high agreement that the type of air attacks to which London and other English cities were subjected during World War II did not produce a sizeable increase in major psychiatric disorders.

The available information on psychiatric air-raid casualties among German civilians is consistent with the British findings. At the end of the war in Europe, the Medical Team of the USSBS sent a questionnaire to German psychiatrists and directors of psychiatric institutions. The "universal reply" to the questionnaire was that "neither organic neurologic diseases nor psychiatric disorders can be attributed to nor are they conditioned by, the air attacks."[8]

A parallel survey of relevant specialists on psychosomatic disorders in Germany revealed some definite wartime trends (which will be discussed later in this chapter), but what is relevant here is the general conclusion: ". . . in view of the tremendous exogenous stimuli which offered a fertile ground for the development of psychosomatic complaints, the relative infrequency of the development

[8] USSBS Report, *The Effect of Bombing on Health and Medical Care in Germany*, U.S. Government Printing Office, Washington, D.C., 1945.

admissions for diseases of the nervous system. The statistics from several cities suggest that during periods of bombing there may have been a slight increase in the number of cases with organic and functional psychosis, but this trend is not consistently borne out. Detailed results are presented from only two psychiatric hospitals. One of the hospitals, in Yokohama, showed that there was a *marked increase* in the number of admissions for schizophrenia, general paresis, and other psychoses during May, 1945, the month during which the city received its most severe bombing. The other psychiatric hospital, in Kobe, showed that during the months of severe bombing attacks there was a *decline* in the number of admissions for psychosis and for all other neuropsychiatric disorders. Although some of the Japanese hospital statistics lend themselves to interpretations about possible causal factors, the evidence is not adequate for ascertaining whether bombing produced any significant changes in the incidence of neuropsychiatric cases. In general, the statistical data from Japan do not contradict the observations reported from England and Germany.

The absence of psychiatric casualties following the one air raid on American territory—the Pearl Harbor attack on December 7, 1941—has been described by Weatherby.[11] On the day of the attack, no patients with war neurosis were brought to the hospital that normally served a majority of American troops stationed at Oahu. During the two weeks following the attack, the number of psychiatric admissions was no greater than during the two weeks preceding the attack.

In evaluating the evidence on psychiatric effects of air warfare, it is necessary to recognize that the information is far from complete and that many of the observations are unsystematic and impressionistic in character. Moreover, the statistical studies of psychiatric casualty rates have been criticized on various grounds as underestimating the actual number of psychiatric casualties to be expected among a civilian population exposed to heavy air raids. Vernon[12]

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[11] F. E. Weatherby, "War Neuroses after Air Attack on Oahu, Territory of Hawaii, Dec. 7, 1941," *War Med.*, Vol. 4, 1943, pp. 270–271.

[12] *Loc. cit.*

If the population of a target city is unprotected, the vast majority would undergo traumatizing experiences of personal involvement in an A-bomb attack. It should be recognized, therefore, that the adequacy of civil defense preparations designed to increase the physical safety of the population have a direct bearing on the emotional impact of an atomic disaster. If a target city cannot be warned and evacuated before an attack is launched, if the residents cannot reach adequate shelters, and if well-trained civil defense teams are not available to carry out the essential operations of disaster control, the devastating consequences cannot be counted solely in terms of the inordinate toll of dead and injured people. The less adequate the physical protection of the population, the higher the incidence of emotional shock and disorganized behavior. In an atomic war, such reactions on a mass scale might become a crucial deterrent to national recovery.[3]

To a very large extent, the *morale* of the survivors of an A-bomb attack will be determined by the effectiveness of civil defense measures. During the air blitz against England it became increasingly apparent that the availability of welfare and relief facilities can play a decisive role in minimizing feelings of bitterness, suspicion, free-floating hostility, and other adverse morale effects.

> The rest centres, the feeding schemes, the casualty services, the compensation grants, and the whole apparatus of the post-raid services both official and voluntary occupied this role of absorbing shock. They took the edge off the calamaties of damage and destruction; they could not prevent, but they helped to reduce, a great deal of distress. Like the civil defence services, these schemes encourage people to feel that they were not forgotten. They render much less likely (in William James' phrase) an "unguaranteed existence," with all its anxieties, its corruptions and its psychological maladies.[4]

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[3] The reassurance value and morale-building effects of various military defense measures are greatly in need of detailed study. It should be clear to the reader that the present study has not gone into military plans for active and passive defense of potential targets.

[4] R. M. Titmuss, *Problems of Social Policy.* His Majesty's Stationery Office, London, 1950.

Proceedings of the Symposium
held at Washington, D. C.
April 19-23, 1965 by the
Subcommittee on Protective Structures,
Advisory Committee on Civil Defense,
National Academy of Sciences—
National Research Council

Protective Structures

for

CIVILIAN POPULATIONS

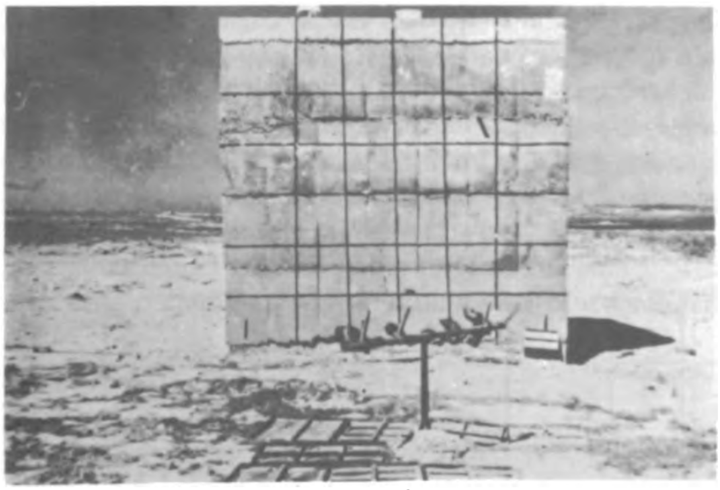
1966

MODEL ANALYSIS

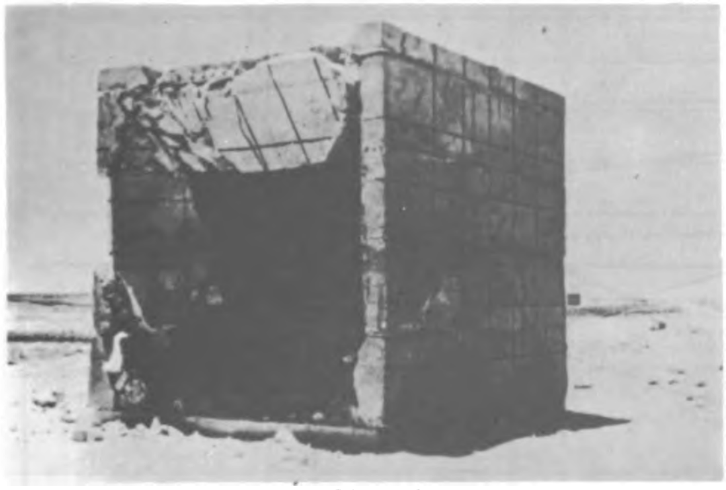
Mr. Ivor Ll. DAVIES
Suffield Experimental Station
Canadian Defense Research Board
Ralston, Alberta, Canada

Nuclear-Weapon Tests

In 1952 we fired our first nuclear device, effectively a "nominal" weapon, at Monte Bello, off northwest Australia. To the blast loading from this weapon we exposed a number of reinforced-concrete cubicle structures that had been designed for the dynamic loading conditions, and for which we made the best analysis of response we were competent to make at that time. Our estimates of effects were really a dismal failure. The structures were placed at pressure levels of 30, 10, and 6 psi, where we expected them to be destroyed, heavily damaged with some petaling of the front face, and extensively cracked, respectively. In fact, the front face of the cubicle at 30 psi was broken inwards; failure had occurred along both diagonals, and the four triangular petals had been pushed in. At the 10-psi level, where we had three cubicles, each with a different wall thickness (6, 9, and 12 in.), we observed only light cracking in the front face of that cubicle with the least thick wall (6 in.). The other two structures were apparently undamaged, as was the single structure at the 6-psi level.



10 p.s.i.



34 p.s.i.

Dynamic tests, Monte Bello cubicles.

In 1957, the first proposals were made for the construction of the underground car park in Hyde Park in London. The Home Office was interested in this project since, in an emergency, the structure could be used as a shelter. Consequently a request was made to us at Atomic Weapons Research Establishment (A.W.R.E.) to design a structure that would be resistant to a blast loading of about 50 psi, and to test our design on the model scale.

Using the various load-deformation curves obtained in this test, an estimate was made of the response of the structure to blast loading. Of particular interest was the possible effect of 100 tons of TNT, the first 100-ton trial at Suffield in Alberta.

A total of seven more models was made; six were shipped to Canada and placed with the top surface of the roof flush with the ground and at positions where peak pressures of 100, 80, 70, 60, 50, and 40 psi were expected. The seventh model was kept in England for static testing at about the time of firing. The results were not as expected. In the field, the four models farthest from the charge were apparently undamaged; we could see no cracking with the eye, nor did soaking the models with water reveal more than a few hair cracks. The model nearest the charge was lightly cracked in the roof panels and beams, and one of the columns showed slight spalling at the head. This model had been exposed to a peak pressure of 110 psi.

BLAST AND OTHER THREATS

Harold Brode
The RAND Corporation, Santa Monica, California

Chemical High-Explosive Weapons

As in past aerial warfare, bombs and missiles carrying chemical explosives to targets are capable of extensive damage only when delivered in large numbers and with high accuracy.

Biological Warfare

Most biological agents are inexpensive to produce; their effective dissemination over hostile territories remains the chief deterrent to their effective employment. Twenty square miles is about the area that can be effectively covered by a single aircraft; large area coverage presents a task for vast fleets of fairly vulnerable planes flying tight patterns at modest or low altitudes. While agents vary in virulence and in their biologic decay rate, most are quite perishable in normal open-air environments. Since shelter and simple prophylactic measures can be quite effective against biological agents, there is less likelihood of the use of biological warfare on a wholesale basis against a nation, and more chance of limited employment on population concentrations —perhaps by covert delivery, since shelters with adequate filtering could insure rather complete protection to those inside.

Chemical Weapons

Chemical weapons, like biological weapons, are relatively inexpensive to create, but face nearly insurmountable logistics problems on delivery. Although chemical agents produce casualties more rapidly, the greater amounts of material to deliver seriously limit the likelihood of their large-scale deployment. Furthermore, chemical research does not hold promise of the development of significantly more toxic chemicals for future use.

Radiological Weapons

The advantages of such modifications are much less real than apparent. In all weapons delivered by missiles, minimizing the payload and total weight is very important. If the total payload is not to be increased, then the inclusion of inert material to be activated by neutrons must lead to reductions in the explosive yield. If all the weight is devoted to nuclear explosives, then more fission-fragment activity can be created, and it is the net difference in activity that must be balanced against the loss of explosive yield. As it turns out, a fission explosion is a most efficient generator of activity, and greater total doses are not achieved by injecting special inert materials to be activated.

Perret, W.R., Ground Motion Studies at High Incident Overpressure, The Sandia Corporation, Operation PLUMBBOB, WT-1405, for Defense Atomic Support Agency Field Command, June 1960.

The Neutron Bomb

The neutron bomb, so called because of the deliberate effort to maximize the effectiveness of the neutrons, would necessarily be limited to rather small yields—yields at which the neutron absorption in air does not reduce the doses to a point at which blast and thermal effects are dominant. The use of small yields against large-area targets again runs into the delivery problems faced by chemical agents and explosives, and larger yields in fewer packages pose a less stringent problem for delivery systems in most applications. In the unlikely event that an enemy desired to minimize blast and thermal damage and to create little local fallout but still kill the populace, it would be necessary to use large numbers of carefully placed neutron-producing weapons burst high enough to avoid blast damage on the ground, but low enough to get the neutrons down. In this case, however, adequate radiation shielding for the people would leave the city unscathed and demonstrate the attack to be futile.

The thermal radiation from a surface burst is expected to be less than half of that from an air burst, both because the radiating fireball surface is truncated and because the hot interior is partially quenched by the megatons of injected crater material.

SUPERSEISMIC GROUND-SHOCK MAXIMA (AT 5-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 340\,\Delta P_s/C_L$ ± 30 per cent. Here acceleration is measured in g's and overpressure (ΔP_s) in pounds per square inch. An empirical refinement requires C_L to be defined as the seismic velocity (in feet per second) for rock, but as three fourths of the seismic velocity for soil.

OUTRUNNING GROUND-SHOCK MAXIMA (AT ~10-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 2 \times 10^5/C_L r^2$ + factor 4 or -factor 2. Acceleration is measured in g's, and r is the scaled radial distance—i.e., $r = R/W^{1/3}$ kft/(mt)$^{1/3}$.

Data taken on a low air-burst shot in Nevada indicate an exponential decay of maximum displacement with depth. For the particular case of a burst of ~ 40 kt at 700 ft, some measurements were made as deep as 200 ft below the surface of Frenchman Flat, a dry lake bed, which led to the following approximate decay law, according to Perret.

$$\delta = \delta_0 \exp(-0.017D),$$

where δ represents the maximum vertical displacement induced at depth D, δ_0 is the maximum displacement at the surface, and D is the depth in feet.

THE PROTECTION AGAINST FALLOUT RADIATION AFFORDED BY CORE SHELTERS IN A TYPICAL BRITISH HOUSE

Daniel T. Jones
Scientific Adviser, Home Office, London

Protective Factors in a Sample of British Houses (Windows Blocked)

Protective Factor	Percentage of Houses
< 25	36%
25-39	28%
40-100	29%
> 100	7%

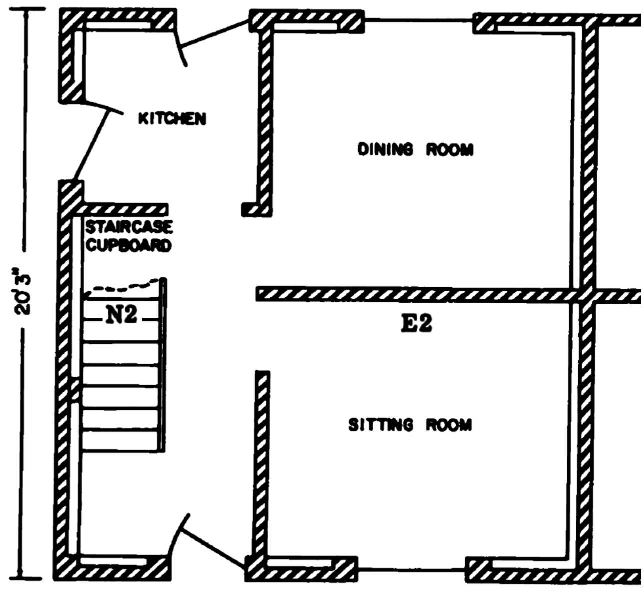
"A very much improved protection could be obtained by constructing a shelter core. This means a small, thick-walled shelter built preferably inside the fallout room itself, in which to spend the first critical hours when the radiation from fallout would be most dangerous."(1)

The full-scale experiments were carried out at the Civil Defense School at Falfield Park.(2)

In the staircase construction, the shelter consisted of the cupboard under the stairs, sandbags being placed on treads above and at the sides.

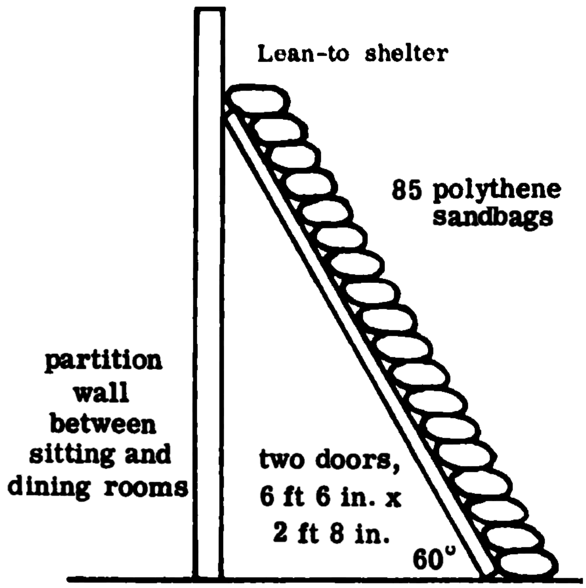
A 93 curies cobalt-60 source was used.

1. Six sandbags per tread, and a double layer on the small top landing. 96 sandbags were used.
2. As (1), together with a 4-ft-high wall of sandbags along the external north wall. 160 sandbags were used.
3. As (2), together with 4-ft-high walls of sandbags along the kitchen/cupboard partition wall and along the passage partition. 220 sandbags were used.



9 in. brick walls The windows and doors were not blocked	Position	contribution r/hr/c/ft^2 Ground	Roof	Protective Factor
House only	E2	15.0	8.4	21
Lean-to	E2	10.4	2.4	39
Staircase cupboard:				
Stairs only sandbagged	N2	29.2	5.3	14
Stairs and outer wall sandbagged	N2	16.4	4.6	24
Stairs, outer wall, kitchen wall and corridor partition sandbagged	N2	8.8	1.8	47

sandbags 24 in. x 12 in. when empty; 16 in. x 9 in. x 4 in. when filled with 25 lb of sand.



floor area 21 sq ft.

1. Civil Defence Handbook No. 10, HMSO, 1963.
2. Perryman, A. D., Home Office Report CD/SA 117.

Foreword

If the country were ever faced with an immediate threat of nuclear war, a copy of this booklet would be distributed to every household as part of a public information campaign which would include announcements on television and radio and in the press. The booklet has been designed for free and general distribution in that event. It is being placed on sale now for those who wish to know what they would be advised to do at such a time.

May 1980

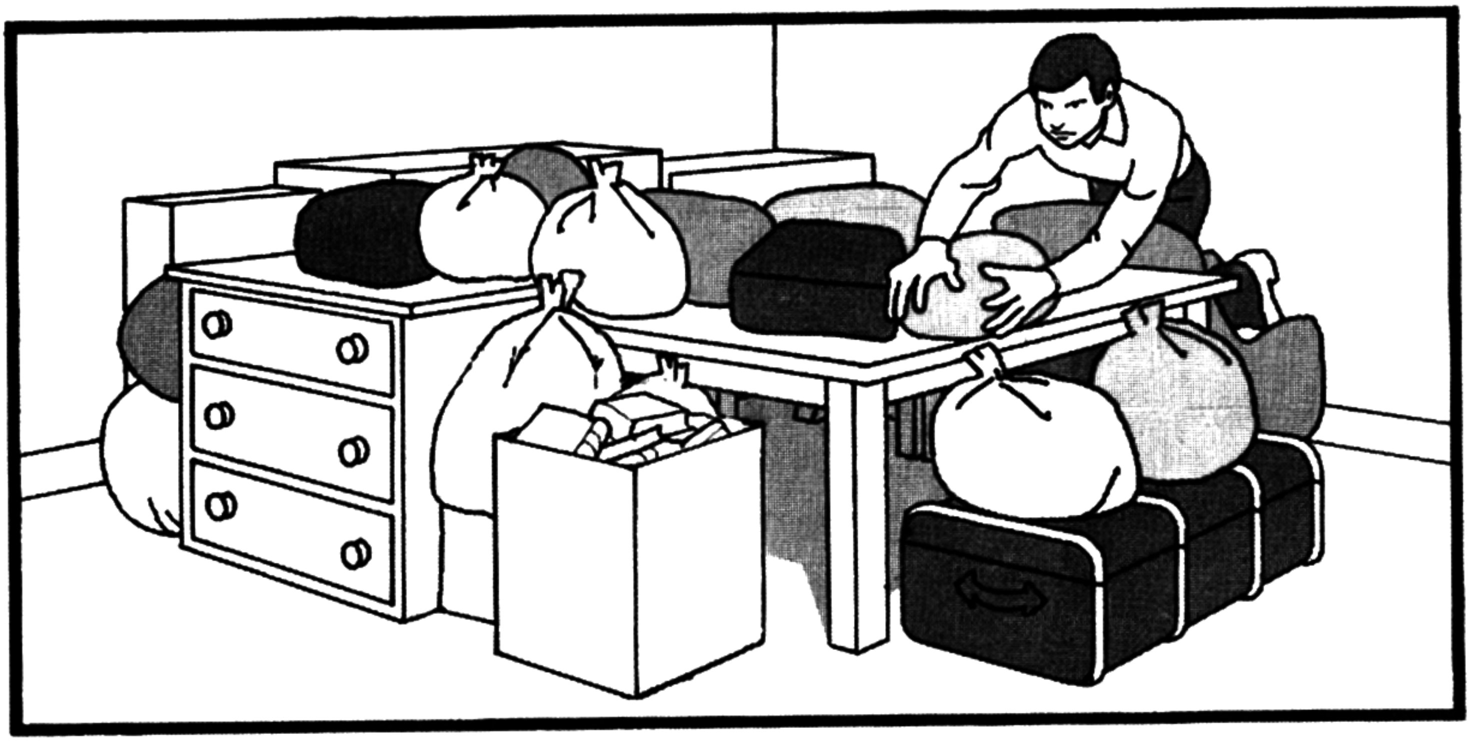
Protect and Survive
ISBN 0 11 3407289

If Britain is attacked by nuclear bombs or by missiles, we do not know what targets will be chosen or how severe the assault will be.

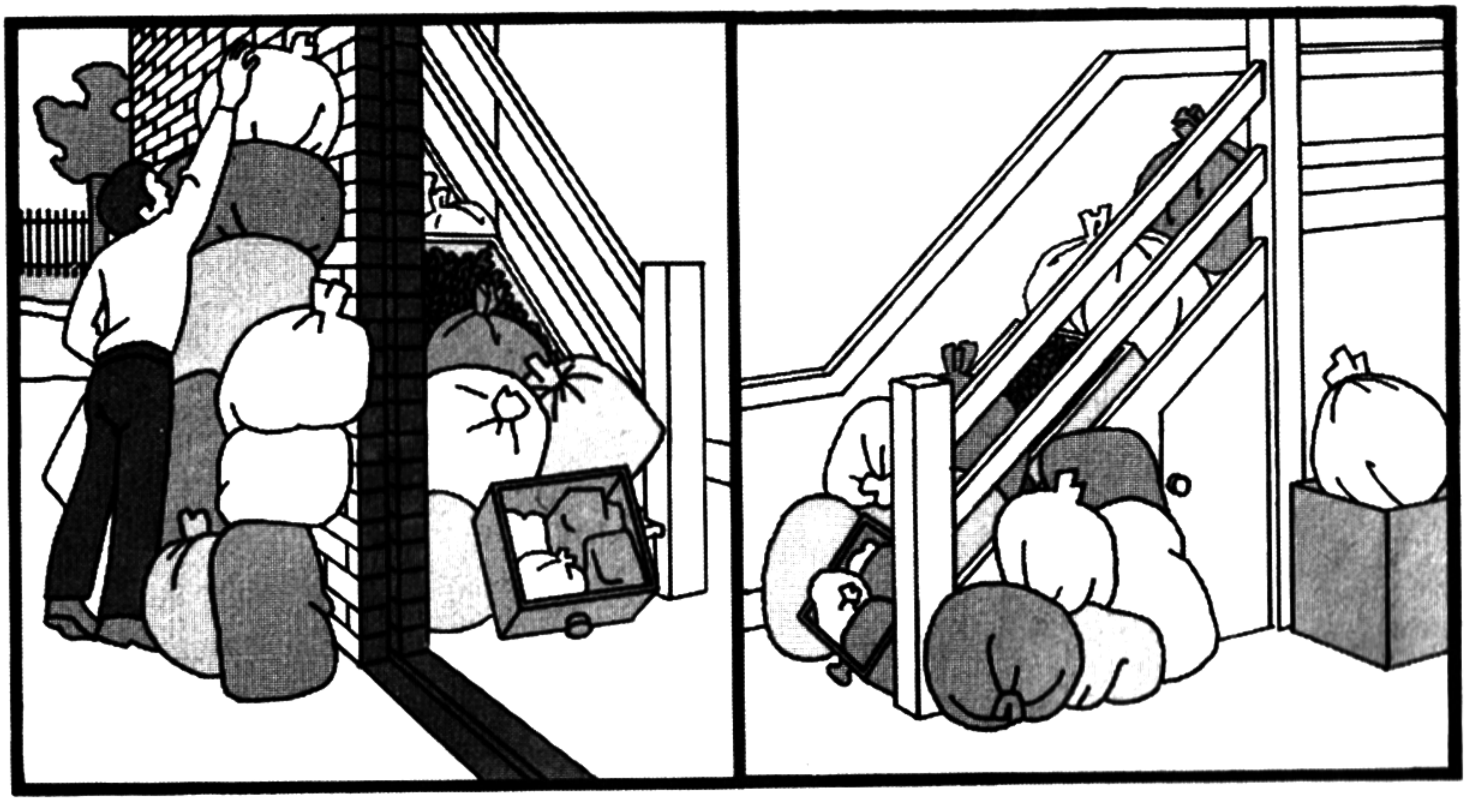
If nuclear weapons are used on a large scale, those of us living in the country areas might be exposed to as great a risk as those in the towns. The radioactive dust, falling where the wind blows it, will bring the most widespread dangers of all. No part of the United Kingdom can be considered safe from both the direct effects of the weapons and the resultant fall-out.

The dangers which you and your family will face in this situation can be reduced if you do as this booklet describes.

Use tables if they are large enough to provide you all with shelter. Surround them and cover them with heavy furniture filled with sand, earth, books or clothing.



Use the cupboard under the stairs if it is in your fall-out room. Put bags of earth or sand on the stairs and along the wall of the cupboard. If the stairs are on an outside wall, strengthen the wall outside in the same way to a height of six feet.



What to do after the Attack:

After a nuclear attack, there will be a short period before fall-out starts to descend. Use this time to do essential tasks. This is what you should do.

Do not smoke.

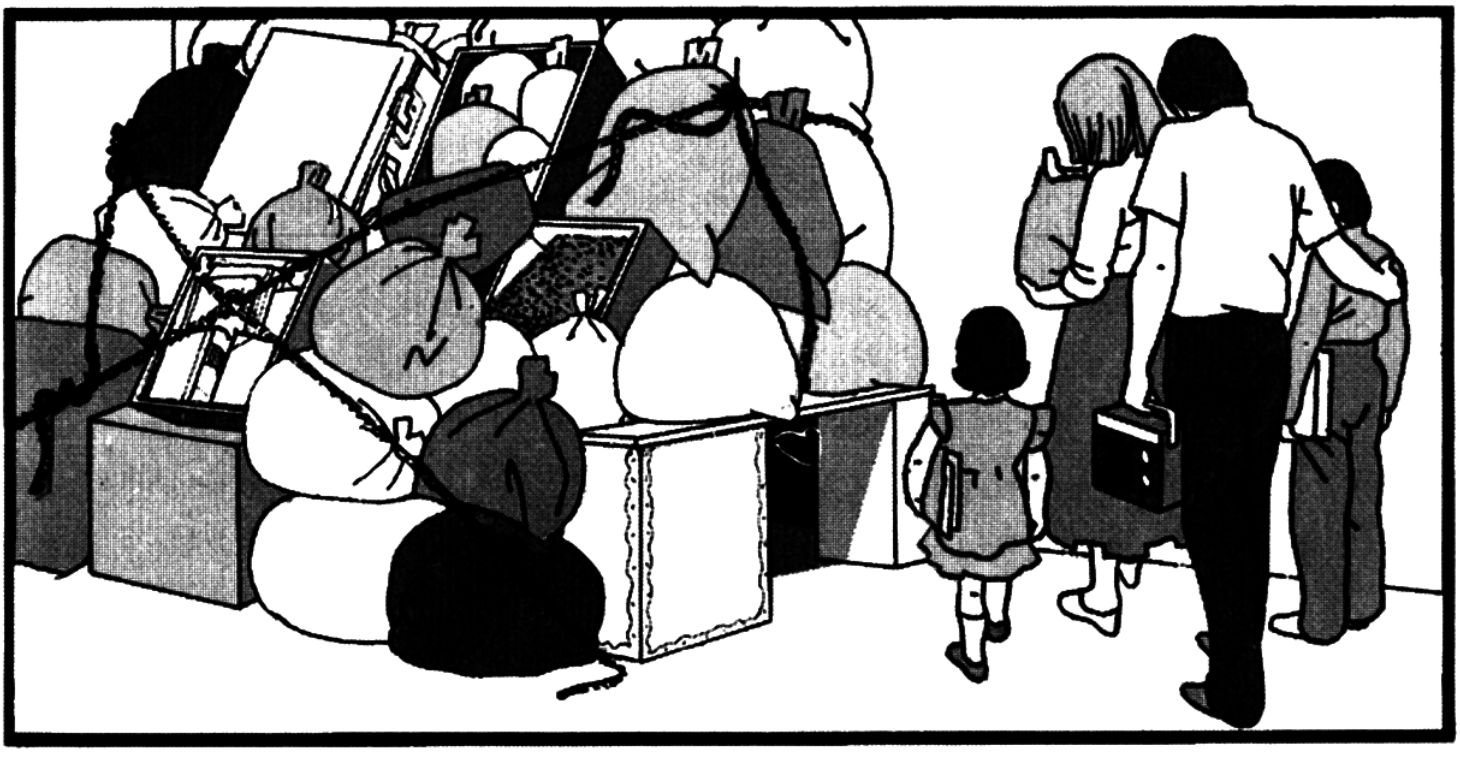
Check that gas, electricity and other fuel supplies and all pilot lights *are* turned off.

Go round the house and put out any small fires using mains water if you can.

If anyone's clothing catches fire, lay them on the floor and roll them in a blanket, rug or thick coat.

If there is structural damage from the attack you may have some time before a fall-out warning to do minor jobs to keep out the weather – using curtains or sheets to cover broken windows or holes.

If you are out of doors, take the nearest and best available cover as quickly as possible, wiping all the dust you can from your skin and clothing at the entrance to the building in which you shelter.



HOME OFFICE

SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON

HER MAJESTY'S STATIONERY OFFICE

1956

The probable fire situation in a British city

35 Japanese houses are constructed of wood and once they were set on fire they continued to burn even when knocked over. In this country only about 10 per cent. of all the material in the average house is combustible, and under conditions of complete collapse, where air would be almost entirely excluded, it is doubtful whether a fire could continue on any vigorous scale.

40 It seems unlikely from the evidence available that an initial density of fires equivalent to one in every other building would be started by a nuclear explosion over a British city. Studies have shown that a much smaller proportion of buildings than this would be exposed to thermal radiation and even then it is not certain that continuing fires would develop. Curtains may catch fire, but it does not necessarily follow that they will set light to the room; in the last war it was found that only one incendiary bomb out of every six that hit buildings started a continuing fire.

From a 10 megaton bomb, with its longer lasting thermal radiation (see paragraph 21), it takes about 20 calories per square centimetre to start fires because so much of the heat (spread out over the longer emission) is wasted by conduction into the interior of the combustible material and by convection and re-radiation whilst the temperature of the surface is being raised to the ignition point. But the distance at which 20 calories per square centimetre can be produced is only 11 miles, so that the scaling factor for a 10 megaton airburst bomb is therefore 11 and not 22.

43 For a ground burst bomb, however, several other factors contribute to a further reduction in the fire range. Apart from an actual loss of heat by absorption into the ground and from the pronounced shielding effect of buildings, the debris from the crater tends to reduce the radiating temperature of the fireball and a greater proportion of the energy is consequently radiated in the infra red region of the spectrum —this proportion being more easily absorbed by the atmosphere.

44 An important point in relation to personal protection against the effects of hydrogen bomb explosions is that because the thermal radiation lasts so long there is more time for people who may be caught in the open, and who may be well beyond the range of serious danger from blast, to rush to cover and so escape some part of the exposure. For example, people in the open might receive second degree burns (blistering) on exposed skin at a range of 16 miles from a 10 megaton ground burst bomb (8×2—see paragraph 24). If, however, they could take cover in a few seconds they would escape this damage. Moreover, at this range the blast wave would not arrive for another minute and a half so that any effects due to the blast in the open (e.g. flying glass, etc.) could be completely avoided.

DOMESTIC NUCLEAR SHELTERS

TECHNICAL GUIDANCE

A HOME OFFICE GUIDE

To obtain some protection from the heat it is necessary to move out of the direct path of the rays from the fireball; any kind of shade will be of some value.

A fire-storm occurred only in an area of several square miles, heavily built up with buildings containing plenty of combustible material and where at least every other building in the area had been set alight. It is not considered that the initial density of fires, equivalent to one in every other building, would be caused by a nuclear explosion over a British city. Studies have shown that due to shielding, a much smaller proportion of buildings than this would be exposed to the heat flash. Moreover, the buildings in the centres of most British cities are now more fire-resistant and more widely spaced than they were 30 to 40 years ago. This low risk of fire-storms would be reduced still further by the control of small initial and secondary fires.

Summary of effects of nuclear weapons

From this brief review of the effects of nuclear weapons we can list the order of events from the detonation of a weapon. These are:

(a) Light and heat flash – immediate, and lasting some seconds.

(c) Blast wave – following from about a half second to several seconds after the light and heat flash.

(d) Fires – these may have been ignited by the heat flash

(e) Fallout – about one half hour to several hours after burst.

Considerations arising from the probable attack pattern

In section 1.1.1 reference was made to the fact that an expected attack pattern on the United Kingdom might use 200 megatons on about 80 targets. If we now make an assumption that this attack would be in the form of 100 weapons of 1 MT airbursts and 100 weapons of 1 MT groundbursts we can use the information given in Fig. 6 to indicate the probability of areas being subject to various effects.

On this assumption, we should find that about 2.2 per cent of the land area of the UK would be subject to overpressures in the 'A' ring of 77 kPa (11 psi) and above about 1.8 per cent would be subject to overpressures of between 42 and 77 kPa (6-11 psi) in the 'B' ring and about 10 per cent of the land area would be subject to overpressures of between 10 and 42 kPa (1.5 to 6 psi). The rest of the land area, about 85 per cent, would be subject to blast in the D ring of 5 to 10 kPa (0.75 to 1.5 psi) or to no blast at all. Blast effects in the D ring will cause minor damage to buildings and no lethalities.

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

UCRL-TR-231593

Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, B. Whitlock

June 7, 2007

An obvious next step (left for future work) would be a calculation of burn injuries and fires. Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

In future work, our code could be extended to tally the total surface area receiving various amounts of heat, and to account for reflected radiation.

References

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2. "RADFLO Physics and Algorithms," E. M. D. Symbalisty, J. Zinn, and R. W. Whitaker, LA-12988-MS (September, 1995).

3. "The Development and Testing of the Air Transport of Radiation Code Version 6 (ATR6)." D. C. Kaul et al., DNA-TR-91-237 (November, 1992).

4. *Handbook of Nuclear Weapon Effects (EM-1)*, J. Northrop, DSWA (1996).

5. http://www.esri.com/

6. L. Davisson and M. Dombroski, private communication; "Radiological and Nuclear Response and Recovery Workshop: Nuclear Weapon Effects in an Urban Environment 2007," M. Dombroski, B. Buddemeier, R. Wheeler, L. Davisson, T. Edmunds, L. Brandt, R. Allen, L. Klennert, and K. Law, UCRL-TR-XXXX (2007), in review.

THERMAL SHIELDING

TENEMENTS, COMMERCIAL, HIRISE

SEPTEMBER 1964

HOME OFFICE

CD/SA 121

SCIENTIFIC ADVISER'S BRANCH

Stanbury, G. R., "Ignition and Fire Spread in Urban Areas Following a Nuclear Attack," Tripartite Thermal Effects Symposium, October 1964.
Symposium on Thermal Effects (Dorking, England, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE

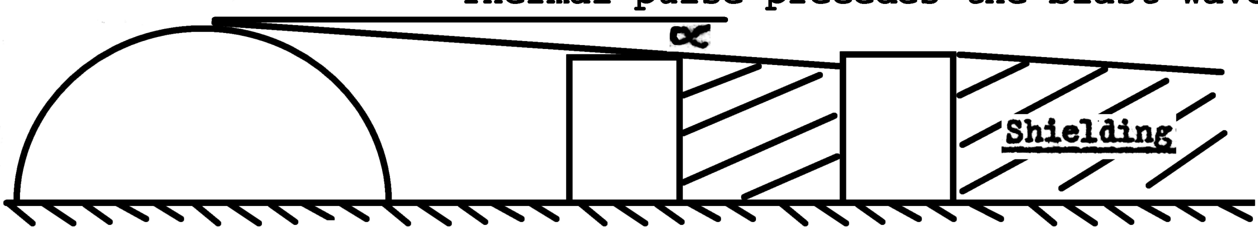
For a 1 MT groundburst bomb the height of the top of the fireball above ground is about 0.72 miles. Because this distance is large compared with the height of most buildings, the exposed upper floors do actually see a large part of the fireball and not just the top of it, but in assuming that the radiation is just as intense from the top as from the middle we were overestimating the fire risk.

On the above basis the following table gives the number of exposed upper floors (to the nearest ½ floor) for a range of distances from the explosion and a range of street widths.

Effect of Shielding: Estimation of the number of exposed floors

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height

Thermal pulse precedes the blast wave



Distance from explosion miles	Angle of arrival $\alpha°$	tan α	Width of street (units of 10 ft.)						
			2	3	4	5	6	7	8
1	35	.72	1.5	2	3	3.5	4.5	5	6
1½	26	.48	1	1.5	2	2.5	3	3.5	4
2	20	.36	.5	1	1.5	2	2	2.5	3
3	13½	.24	.5	.5	1	1	1.5	1.5	2
4	10	.18	.5	.5	.5	1	1	1.5	1.5
5	8	.15	.5	.5	.5	.5	1	1	1

we take the average depth of a floor to be 10 ft.

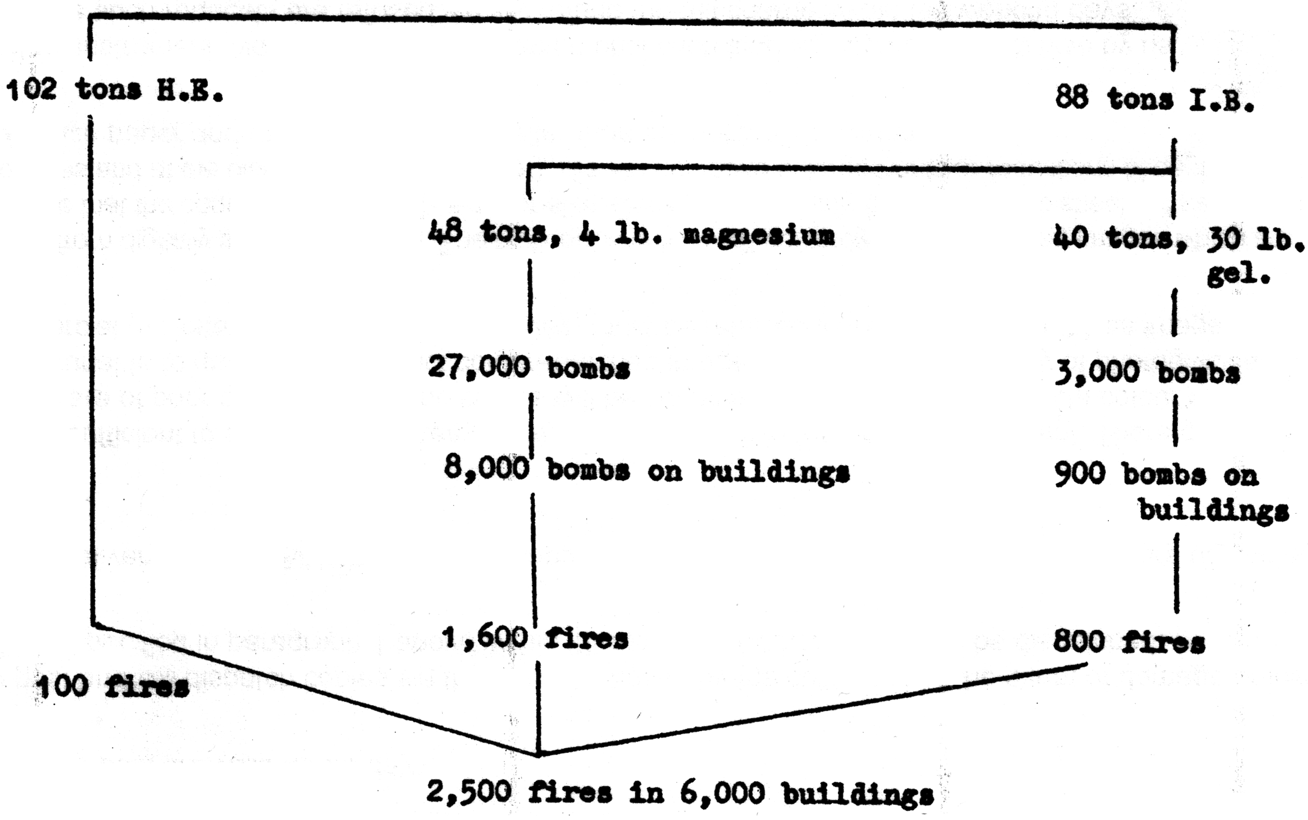
Angle between heat flash and street (degrees)	90-75	75-60	60-45	45-30	30-15	15-0
Proportion of heat flash entering windows %	99	92.5	80	60	40	14

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the fire-storm raid on Hamburg, 27th/28th July, 1943

Bombs dropped



However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire during the raid itself. When this happened no fire-fighting organisation, however efficient could hope to prevent the fires from joining together and engulfing the whole area.

When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of $\sim$ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

Fire situation from 1,499 fly bombs in the built-up part of the London Region

WWII V1 high explosives (1 ton TNT warhead) (cruise missiles)

Where dropped	Number of fly bombs	Fly Bombs Caused				
		No fire	Small fire	Medium fire	Serious fire	Major fire
City	119 ~~199~~	47	49	17	4	2
West-End	33	8	22	2	-	1
Closed Residential	430	207	203	20	-	-
Open Residential	804	478	296	28	2	-
Docks	113	64	39	8	1	1
Grand Totals	1,499	804	609	75	7	4

Discussion of results

Two important points emerge from a study of these results:-

(i) The small proportion of fly bombs - less than 20% - which started fires of any greater category than "small" even in the most heavily built-up areas; and

(ii) The large proportion which started no fires at all even in the most heavily built-up areas.

All these fly bombs fell in the summer months of 1944 which were unusually dry. In winter in this country in residential areas there are many open fires which may provide extra sources of ignition. The domestic occupancy is a low fire risk however, and as the proportion of such property in the important City and West End areas is small this should not introduce any serious error. Moreover, in winter, the high atmospheric humidity and the correspondingly high moisture content of timber would tend to retard or even prevent the growth of fire.

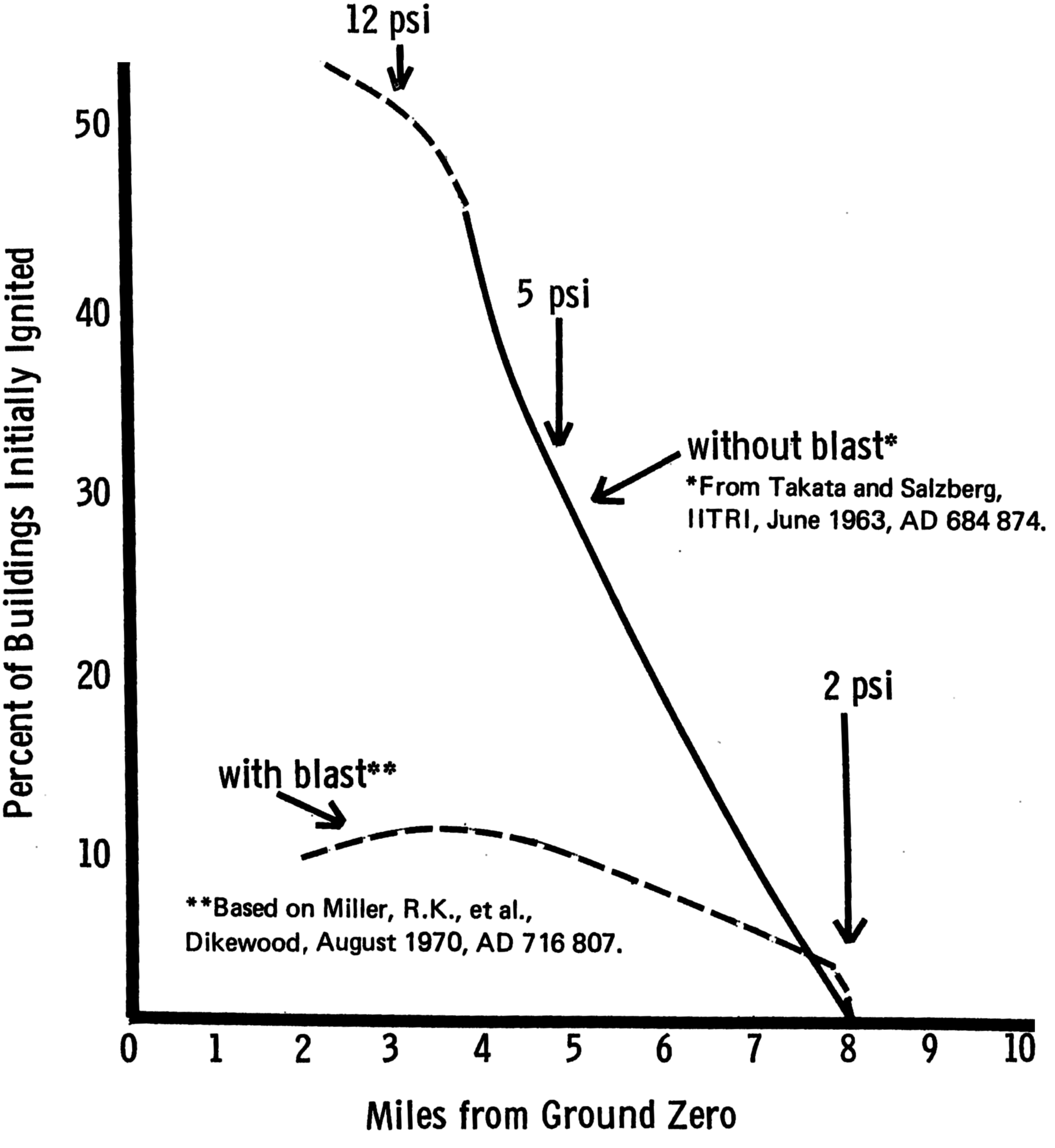
In order to determine how many fly bombs are equivalent to one nominal atomic bomb one method is to compare the areas over which a given category of house damage is produced by each. If we do this for a $\frac{3}{8}$th mile air burst as at Hiroshima, the result is that 1 atomic bomb does as much damage as about 1,200 fly bombs.

This in itself is not a serious fire situation and it is doubtful whether it could ever give rise to a fire storm. In Hamburg 2,500 fires were started per square mile by a bomb density (combined H.E. and I.B.) of 200 tons per square mile, and for the area of destruction produced by an atomic bomb this would correspond to a total of about 10,000 fires.

Overall, a review of past experience suggests that about six significant "secondary" fires can be expected in each million square feet of building floor area in the damaged area.

From McAuliffe and Moll, **Secondary Ignitions in Nuclear Attack**, Stanford Research Institute, July 1965, AD 625 173.

5-MT SURFACE BURST IN DETROIT



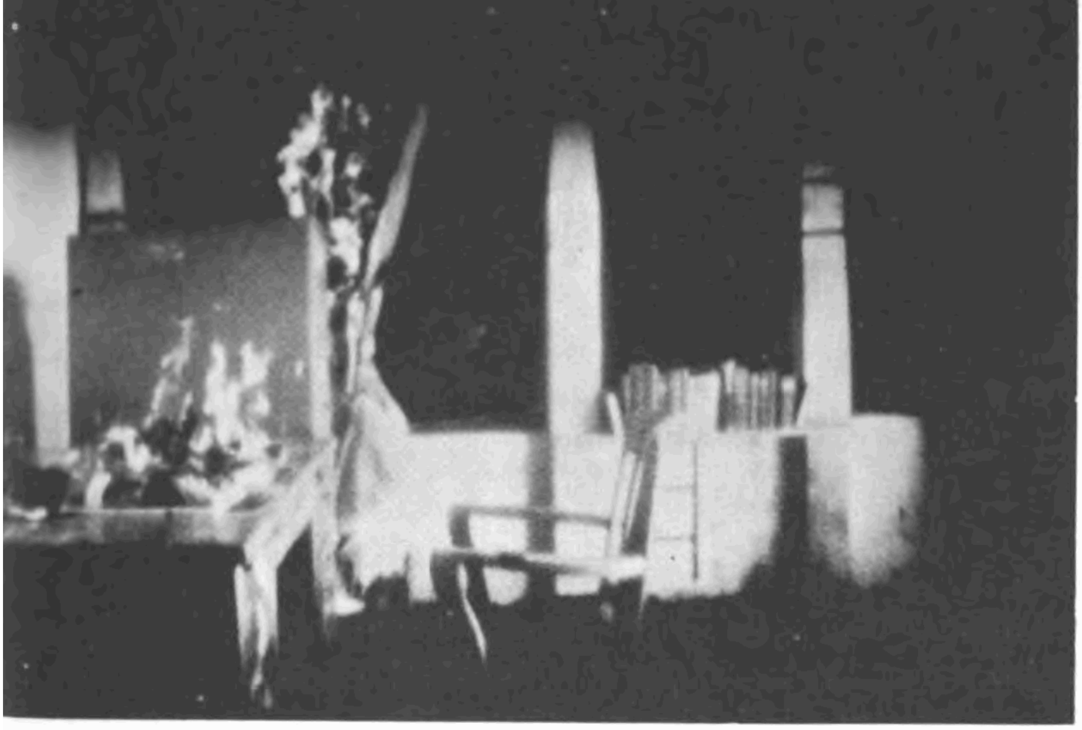
CRITERIA FOR PREDICTING FIRESTORMS*

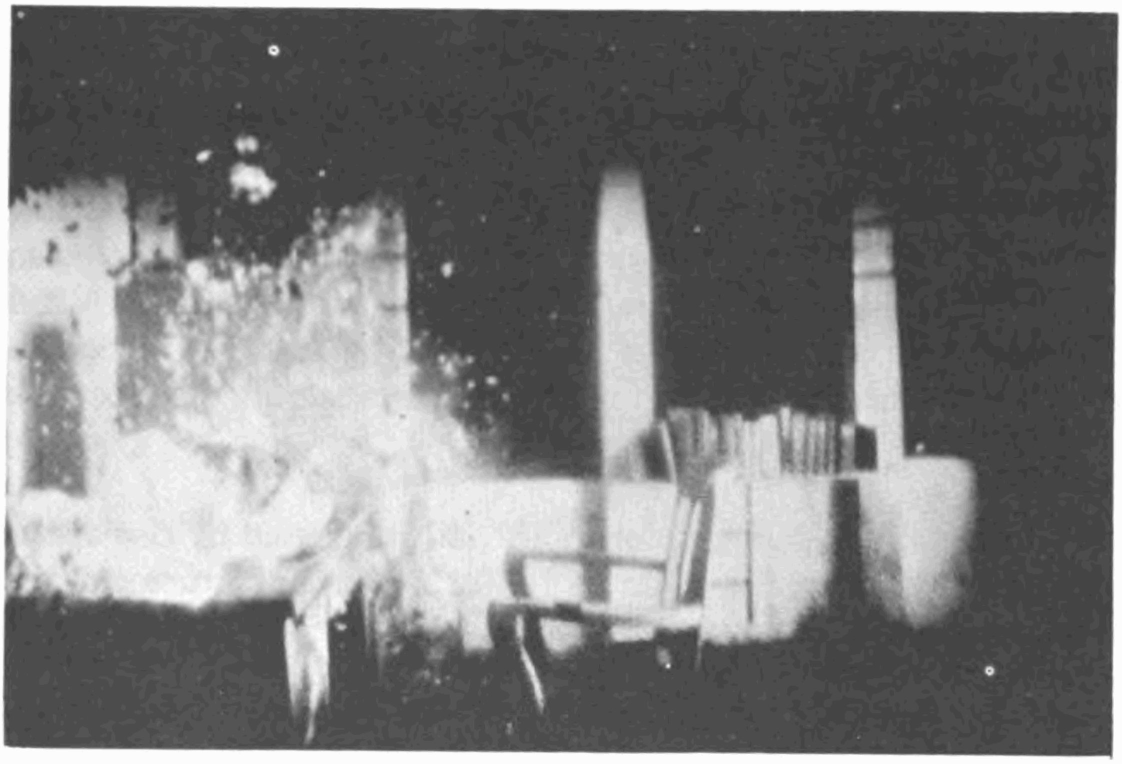
- Greater than 50 percent of structures on fire initially.

*Rodden, R.M., et al, **Exploratory Analysis of Fire Storms**, Stanford Research Institute, 1965, AD 616 638.

EFFECTS OF 1 PSI OVERPRESSURE ON IGNITIONS

From: Goodale, Effects of Air Blast on Urban Fires URS 7009–14 Dec. 1970 (AD 723 429)





The Effects of

Nuclear Weapons

SAMUEL GLASSTONE

Editor

Revised Edition

Reprinted February 1964

Prepared by the

UNITED STATES DEPARTMENT OF DEFENSE

Published by the

UNITED STATES ATOMIC ENERGY COMMISSION

April 1962

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Washington 25, D.C. - Price $3.00 (paper bound)

Foreword

This book is a revision of "The Effects of Nuclear Weapons" which was issued in 1957. It was prepared by the Defense Atomic Support Agency of the Department of Defense in coordination with other cognizant governmental agencies and was published by the U.S. Atomic Energy Commission. Although the complex nature of nuclear weapons effects does not always allow exact evaluation, the conclusions reached herein represent the combined judgment of a number of the most competent scientists working on the problem.

There is a need for widespread public understanding of the best information available on the effects of nuclear weapons. The purpose of this book is to present as accurately as possible, within the limits of national security, a comprehensive summary of this information.

Secretary of Defense

Chairman
Atomic Energy Commission

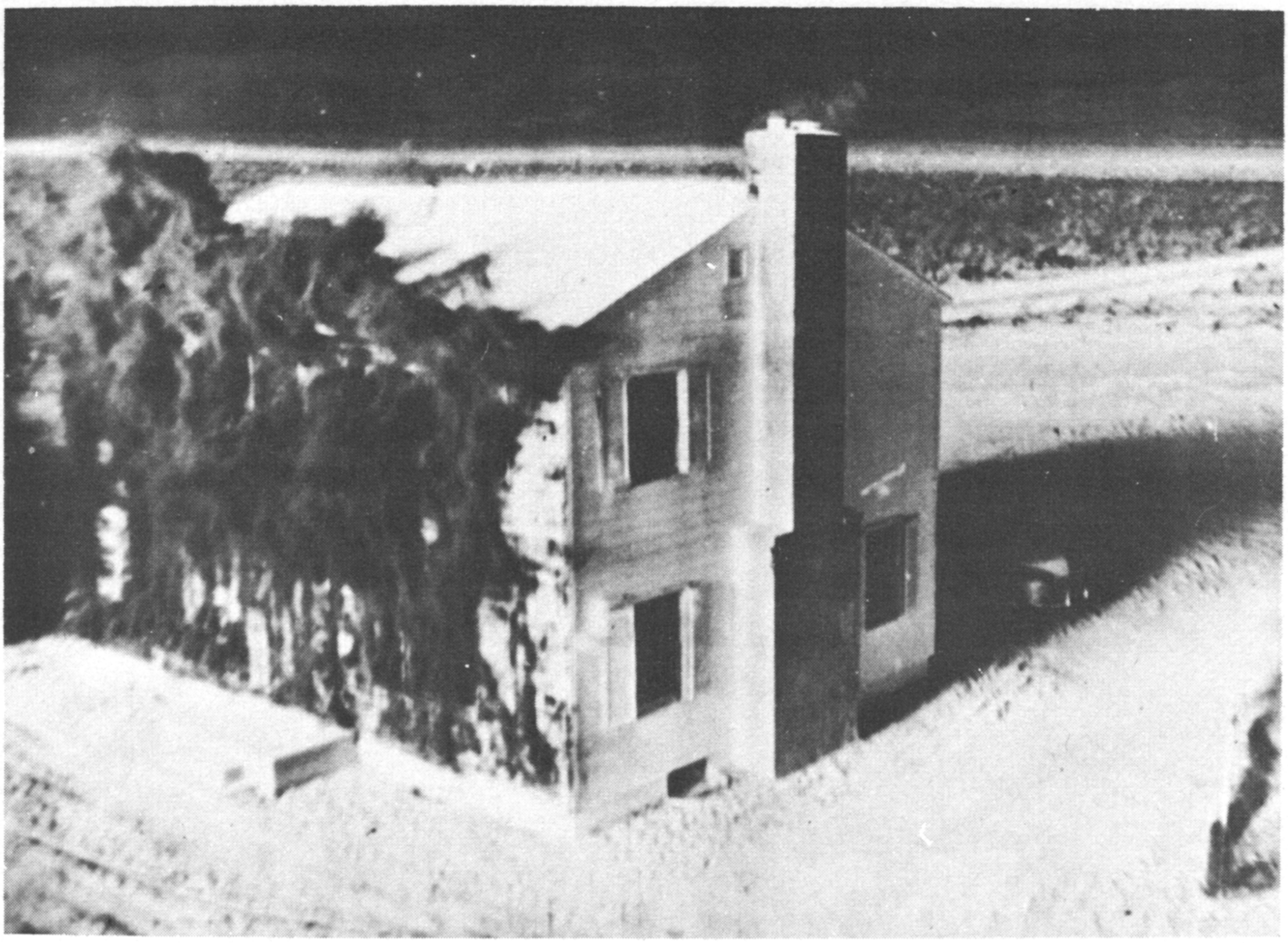


Figure 7.33a. Thermal effects on wood-frame house 1 second after explosion (about 25 cal/sq cm).

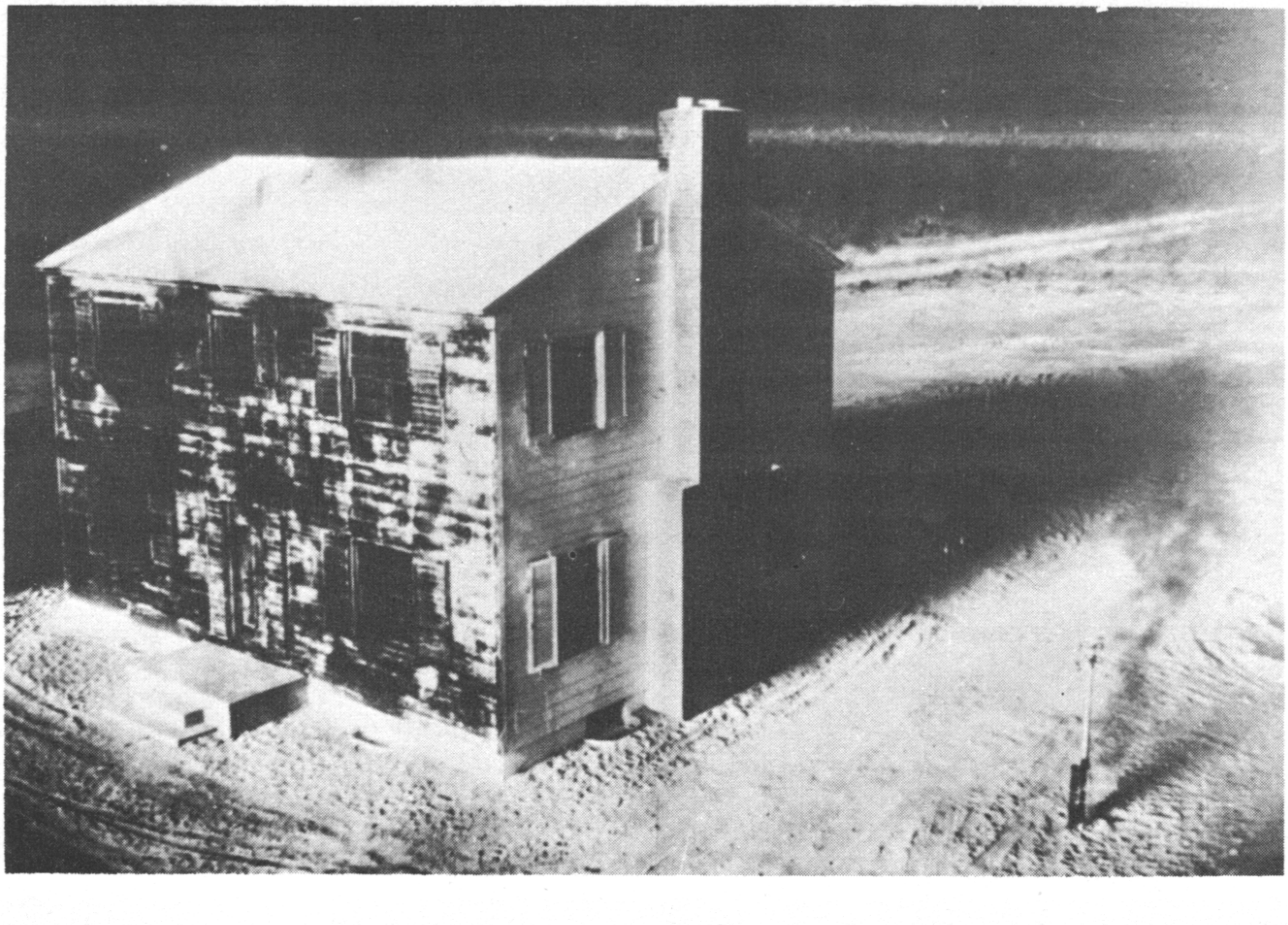


Figure 7.33b. Thermal effects on wood-frame house about ¾ second later.

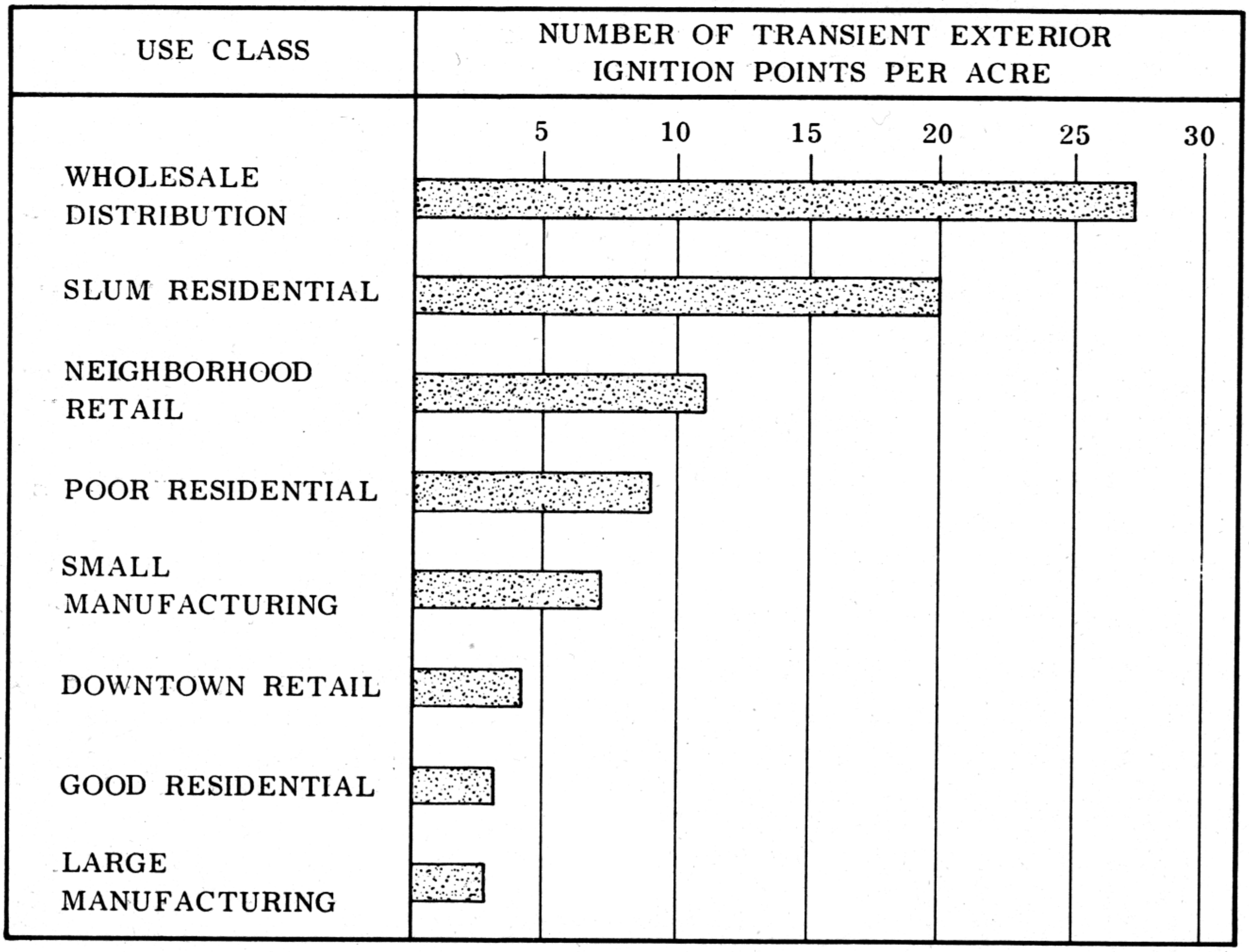


Figure 7.55. Frequency of exterior ignition points for various areas in a city

the formation of a significant fire, capable of spreading, will require appreciable quantities of combustible material close by, and this may not always be available.

7.57 The fact that accumulations of ignitable trash close to a wooden structure represent a real fire hazard was demonstrated at the nuclear tests carried out in Nevada in 1953. In these tests, three miniature wooden houses, each having a yard enclosed with a wooden fence, were exposed to 12 calories per square centimeter of thermal radiation. One house, at the left of Fig. 7.57, had weathered siding showing considerable decay, but the yard was free from trash. The next house also had a clean yard and in addition, the exterior siding was well maintained and painted. In the third house, at the right of the photograph, the siding, which was poorly maintained, was weathered, and the yard was littered with trash.

7.58 The state of the three houses after the explosion is seen in Fig. 7.58. The third house, at the right, soon burst into flame and was burned to the ground. The first house, on the left, did ignite but it did not burst into flame for 15 minutes. The well maintained house in the center with the clean yard suffered scorching only. It is of interest to recall that the wood of a newly erected white-painted

Figure 7.57. Wooden test houses before exposure to a nuclear explosion, Nevada Test Site.

Figure 7.58. Wooden test houses after exposure to a nuclear explosion.

house exposed to about 25 calories per square centimeter was badly charred but did not ignite (see Fig. 7.33b).

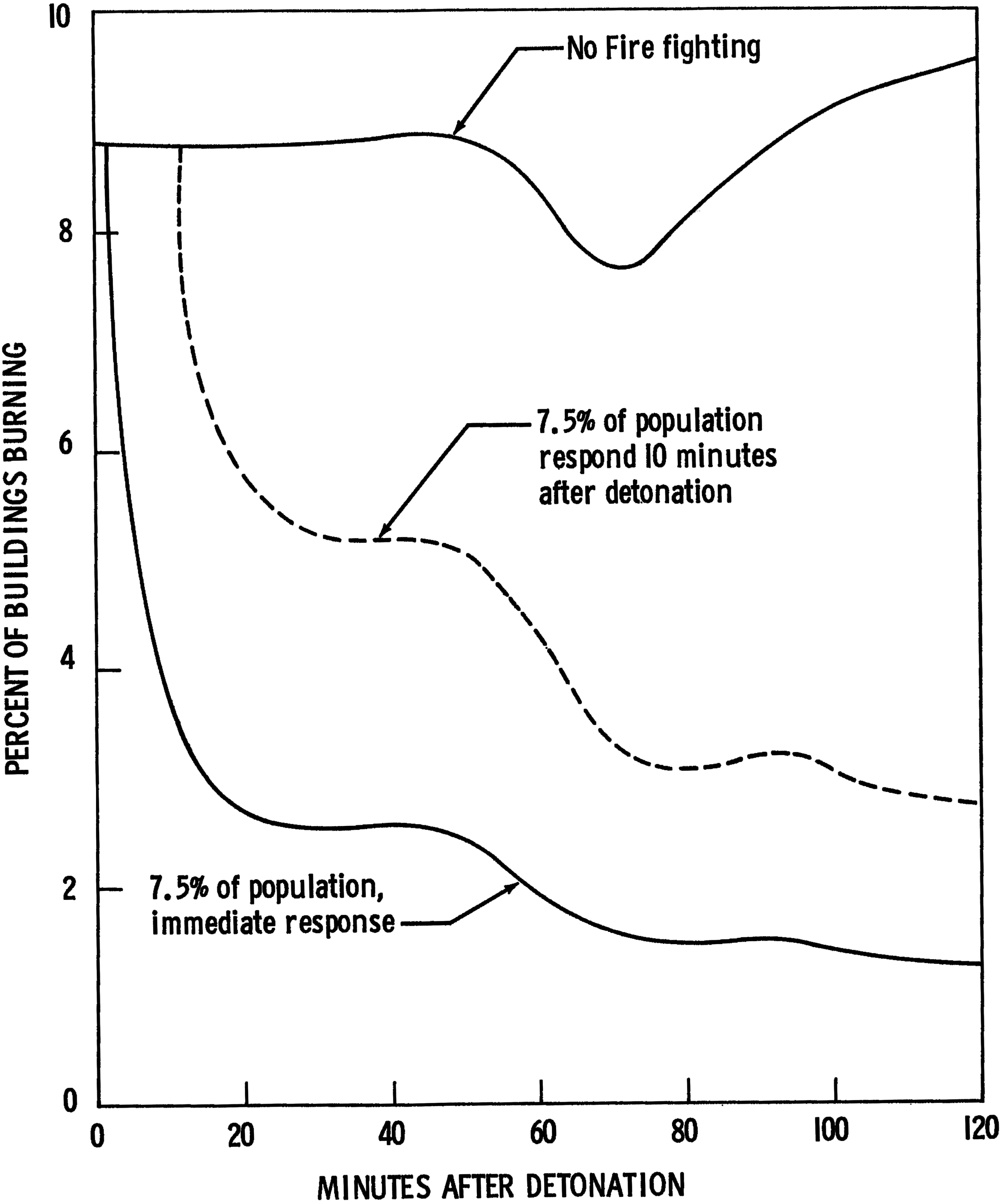
7.59 The value of fire-resistive furnishing in decreasing the number of ignition points was also demonstrated in the tests. Two identical, sturdily constructed houses, each having a window 4 feet by 6 feet facing the point of burst, were erected where the thermal radiation exposure was 17 calories per square centimeter. One of the houses contained rayon drapery, cotton rugs, and clothing, and, as was expected, it burst into flame immediately after the explosion and burned completely. In the other house, the draperies were of vinyl plastic, and rugs and clothing were made of wool. Although much ignition occurred, the recovery party, entering an hour after the explosion, was able to extinguish the fires.

7.76 It should be noted that the fire storm is by no means a special characteristic of nuclear weapons. Similar fire storms have been reported as accompanying large forest fires in the United States, and especially after incendiary bomb attacks in both Germany and Japan during World War II. The high winds are produced largely by the updraft of the heated air over an extensive burning area. They are thus the equivalent, on a very large scale, of the draft of a chimney under which a fire is burning. Because of limited experience, the conditions for the development of fire storms in cities are not well known. It appears, however, that some, although not necessarily all, of the essential requirements are the following: (1) thousands of nearly simultaneous ignitions over an area of at least a square mile, (2) heavy building density, e.g., more than 20 percent of the area is covered by buildings, and (3) little or no ground wind. Based on these criteria, only certain sections—usually the older and slum areas—of a very few cities in the United States would be susceptible to fire storm development.

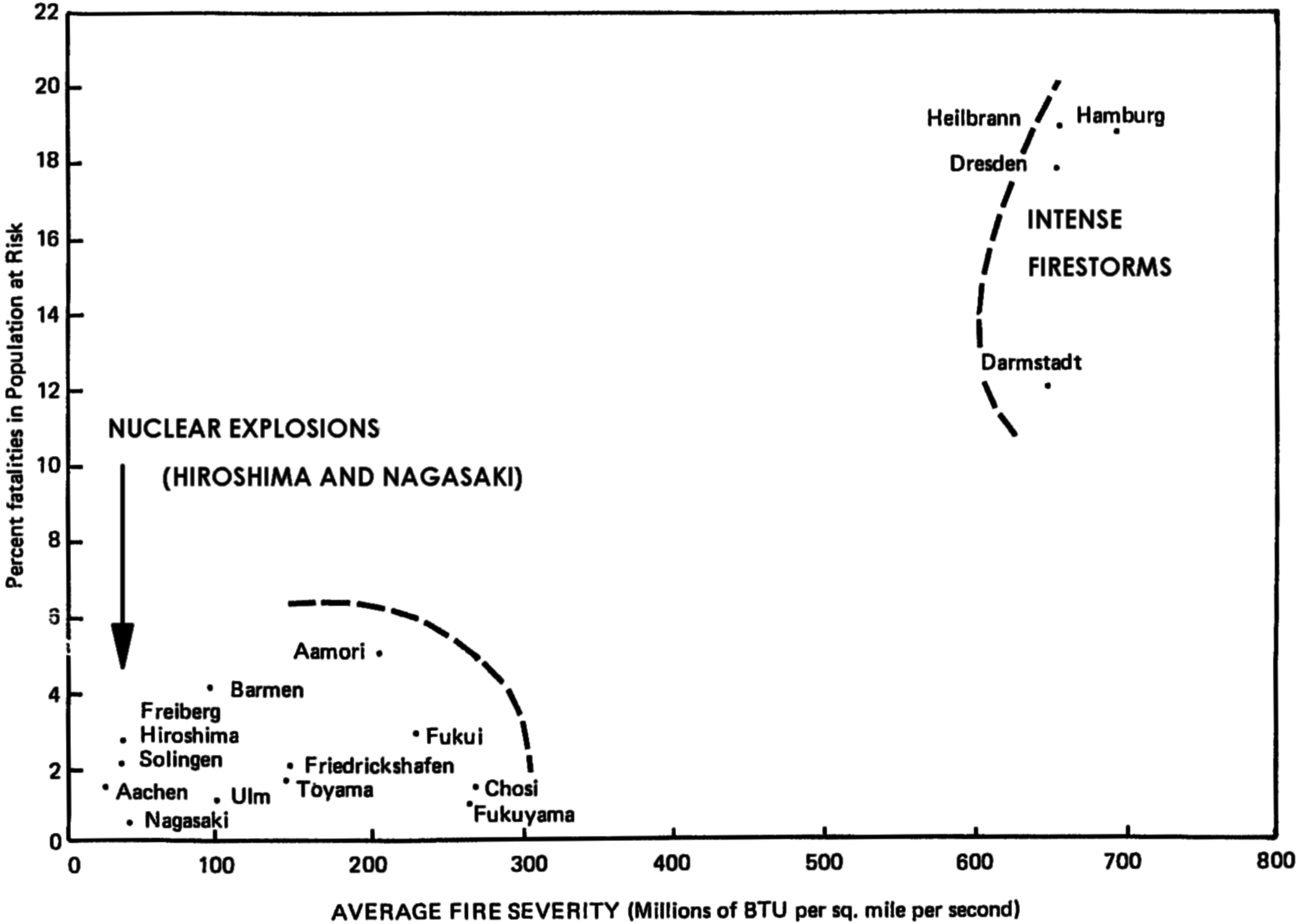
12.35. The major part of the thermal radiation travels in straight lines, and so any opaque object interposed between the fireball and the exposed skin will give some protection. This is true even if the object is subsequently destroyed by the blast, since the main thermal radiation pulse is over before the arrival of the blast wave.

12.36 At the first indication of a nuclear explosion, by a sudden increase in the general illumination, a person inside a building should immediately fall prone, as described in § 12.30, and, if possible, crawl behind or beneath a table or desk or to a planned vantage point. Even if this action is not taken soon enough to reduce the thermal radiation exposure greatly, it will minimize the displacement effect of the blast wave and provide a partial shield against splintered glass and other flying debris. An individual caught in the open should fall prone to the ground in the same way, while making an effort to shade exposed parts of the body. Getting behind a tree, building, fence, ditch, bank, or any structure which prevents a direct line of sight between the person and the fireball, if possible, will give a major degree of protection. If no substantial object is at hand, the clothed parts of the body should be used to shield parts which are exposed.

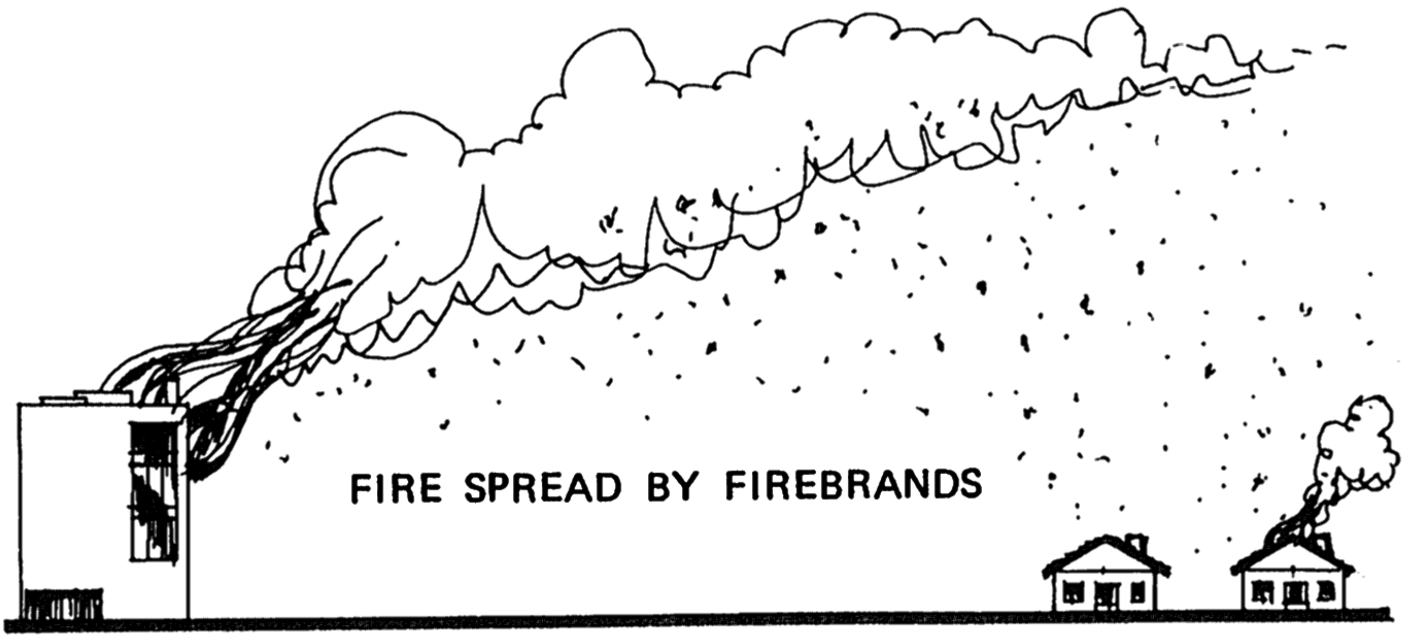
Takata, A.N., **Mathematical Modeling of Fire Detenses, IITRI, March 1970, AD 705 388.**

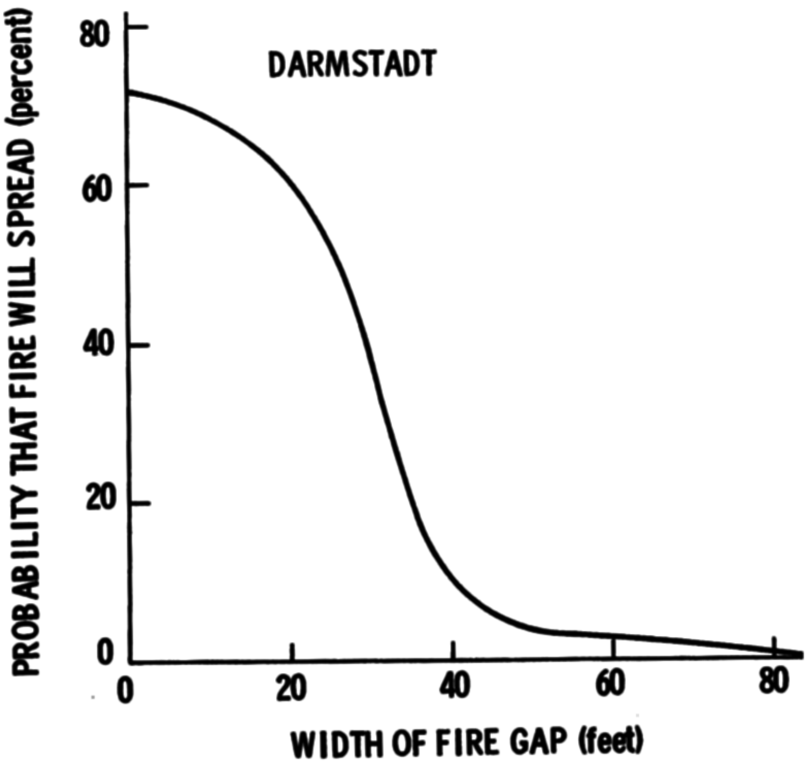


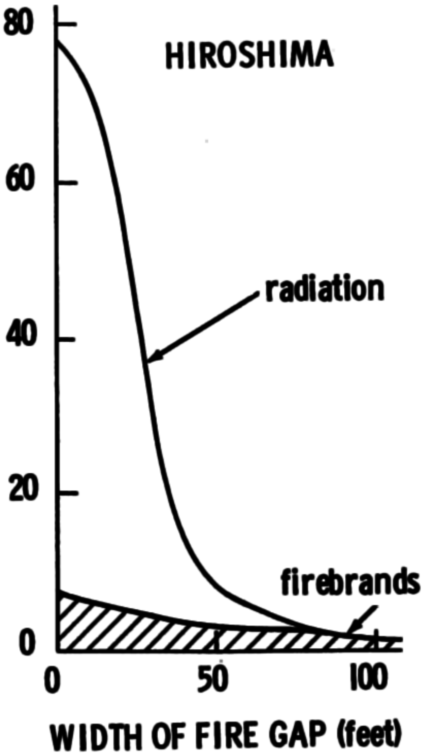
FATALITIES IN WORLD WAR II FIRES*



*Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions**, Dikewood Corporation, DC-TN-1058-1, December 1966.







Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, IITRI, June 1968, AD 684 874.

ADA383988

November 1963
Second printing May 1964

Unclassified Version

SURVEY OF THE THERMAL THREAT OF NUCLEAR WEAPONS

Prepared for:

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF DEFENSE
WASHINGTON 25, D.C.

By: Jack C. Rogers and T. Miller

SRI Project No. IMU-4021

Approved:

Robert A. Harker

ROBERT A. HARKER, DIRECTOR
MANAGEMENT SCIENCES DIVISION

OCD REVIEW NOTICE

This report represents the authors' views, which in general are in harmony with the technical criteria of the Office of Civil Defense. However, a preliminary evaluation by OCD indicates the need for further evaluation of the fire threat of nuclear weapons and formulation of promising research and action programs.

Table B-VII

COMPARISON OF ESTIMATES FOR IGNITION ENERGY REQUIREMENTS
(10 mt)

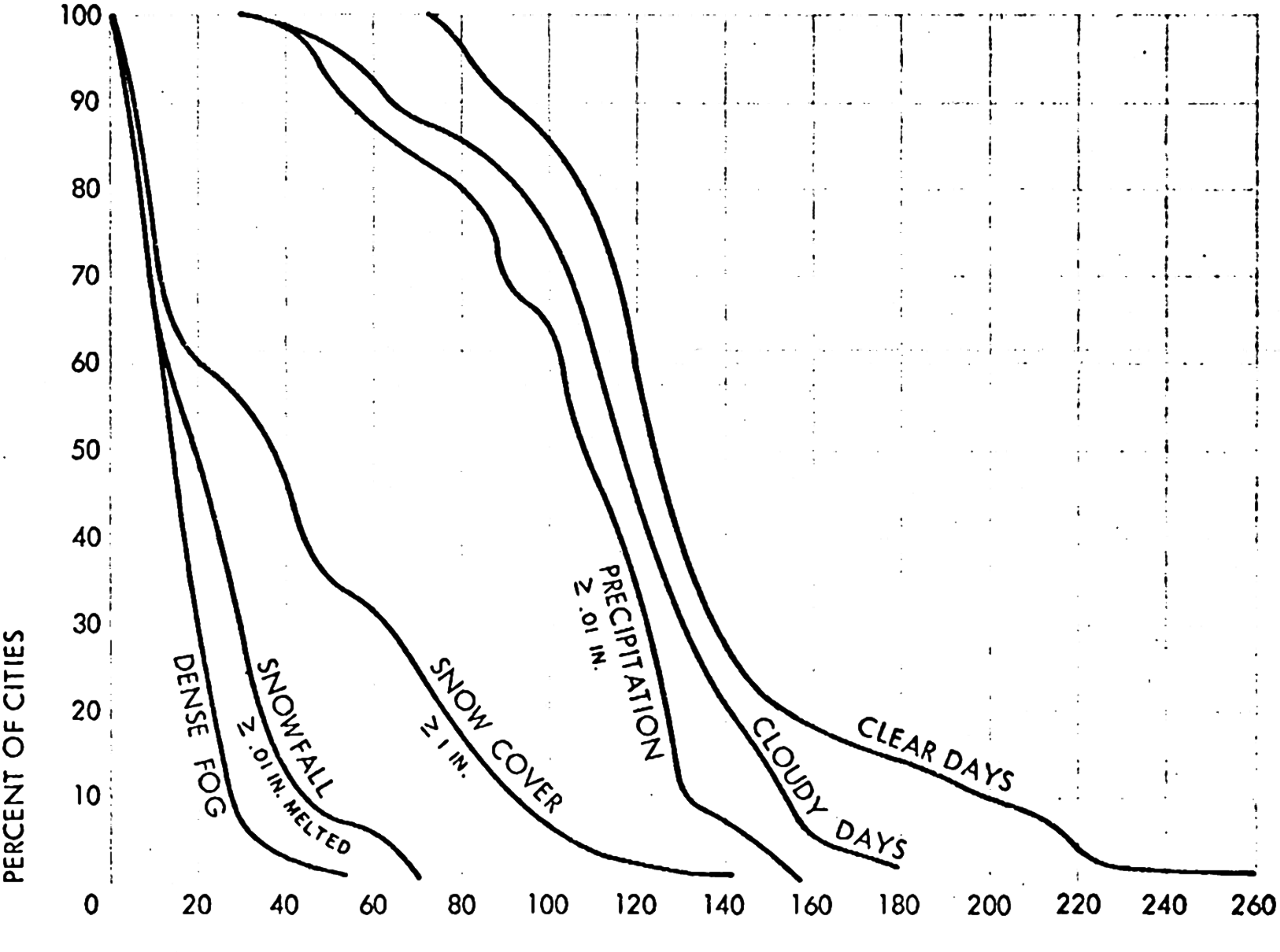
The Effects of Nuclear Weapons		Naval Radiological Defense Laboratory		
Material	Cal/cm^2 for Ignition	Material	Cal/cm^2 for Ignition	Ratio of NRDL to ENW
Cotton auto seat upholstery, green, brown, white	16	Heavy cotton draperies, dark color	28	1.75
Wool pile chair upholstery, wine	35 (not sustained)	Wool pile chair upholstery, dark color	25	0.7
Newspaper, single sheet	6	Newspaper, medium printed	40	6.7
		Newspaper, dark areas	30	5.
Kraft paper carton, flat side exposed, used, brown	15	Corrugated Kraft board	40	2.6
Deciduous leaves	12	Walnut leaves	54	4.5
		Beech leaves	36	3.
Coarse grass	16	Harding grass	44	2.7
Ponderosa pine needles, brown	18	Pine needles	50	2.7

Sources: Martin, et al. (1959) and Glasstone (1962).

Martin, S. B., On Predicting the Ignition Susceptibility of Typical Kindling Fuels to Ignition by the Thermal Radiation from Nuclear Detonations, Tech. Report 367, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., April 1959. (U)

Figure C-1

CLIMATE SUMMARY
(cities larger than 100,000 population)



SOURCES: Climate and Man... (1941), Visher (1954) and Stanford Research Institute

Prediction of Fire Spread Following Nuclear Explosions

Final Report
for
Office of Civil Defense
U.S. Department of Defense
Contract OCD-OS-62-131

OCD REVIEW NOTICE
This report has been reviewed in the Office of Civil Defense and approved for publication.

Pacific Southwest Forest and Range Experiment Station - Berkeley, California

Forest Service - U. S. Department of Agriculture

U. S. Forest Service Research Paper PSW-5 1963

The Authors

Craig C. Chandler is a fire behavior specialist with first-hand experience on more than 30 major fires. After graduating from the University of California with a B.S. degree in forestry (1951), he joined the Experiment Station in Berkeley, taught at the University of California School of Forestry (1953–1956), returned to the Forest Service, and became project leader of conflagration control research at the Pacific Southwest Station. He is the principal author of the sections on wildland fires in this report.

Theodore G. Storey has specialized in forest fire research since joining the Forest Service at Berkeley in 1949. In 1955, he transferred to the Southeastern Station, Asheville, N. C. He worked at the forest fire laboratory in Macon, Ga., for three years before returning to the Pacific Southwest Station in 1962. A forestry graduate of the University of California, he produced the sections on urban fires in this report.

Charles D. Tangren is a mathematician, and prepared the data analyses in this report. He was graduated from California State Polytechnic College in 1961 with a B.S. degree in mathematics. He began working for the Pacific Southwest Station as a research technician, and was promoted to his present position in 1962.

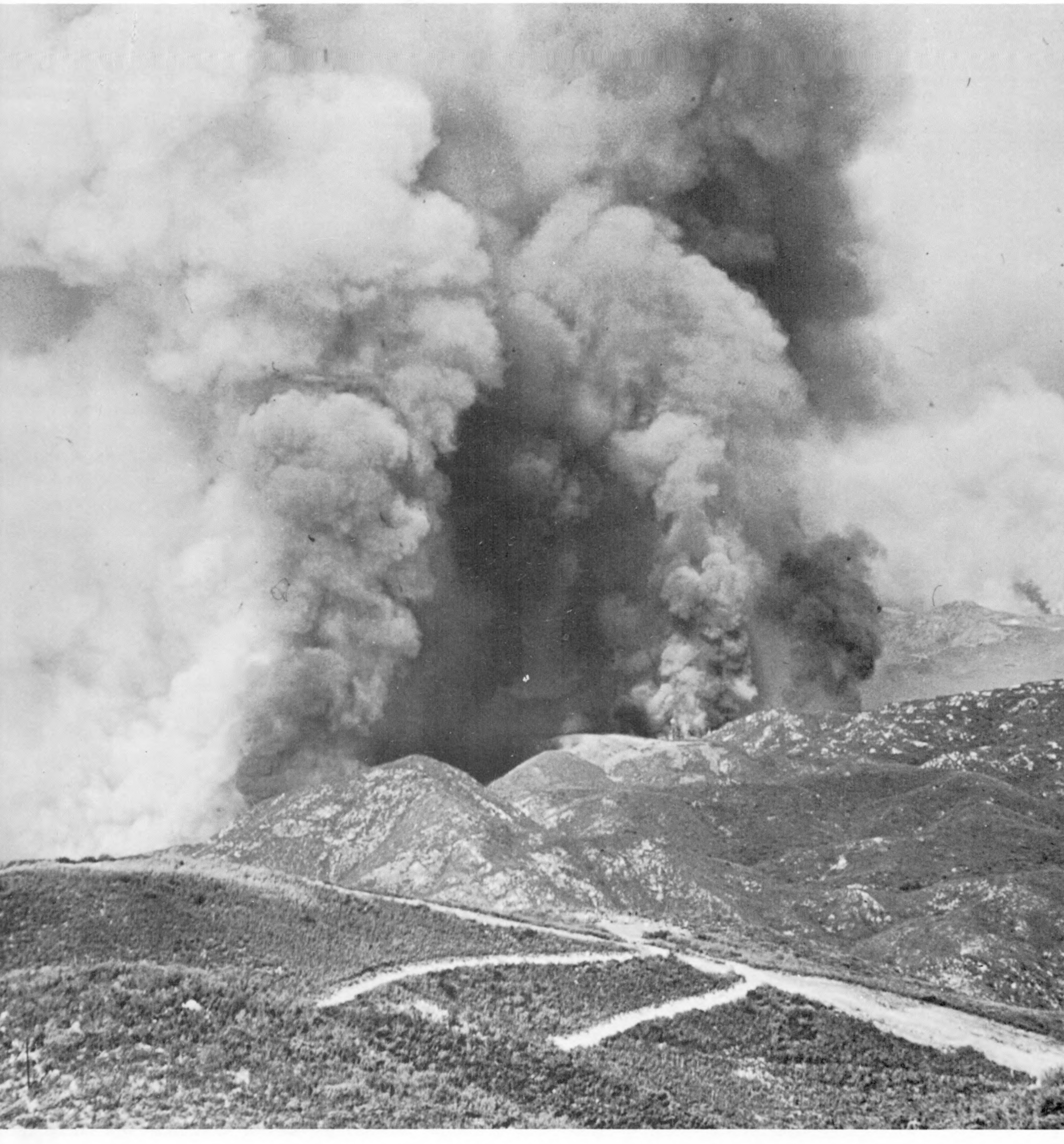


Figure 1.—Stewart Fire, Cleveland National Forest, California, December 17, 1958.

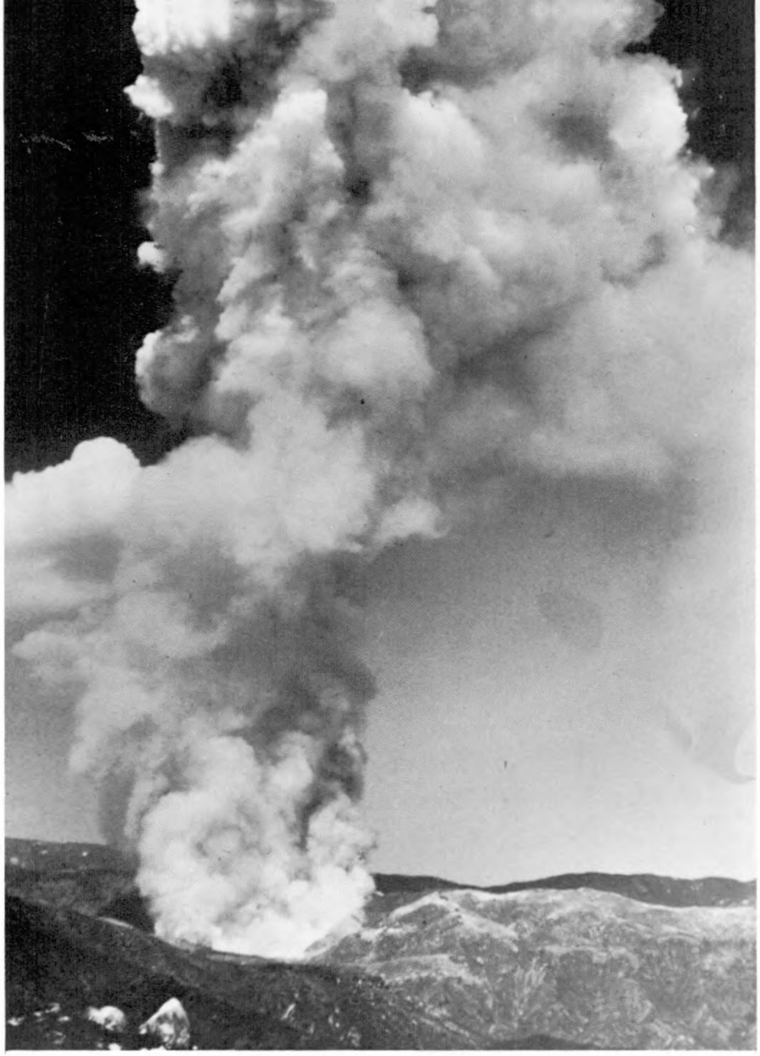
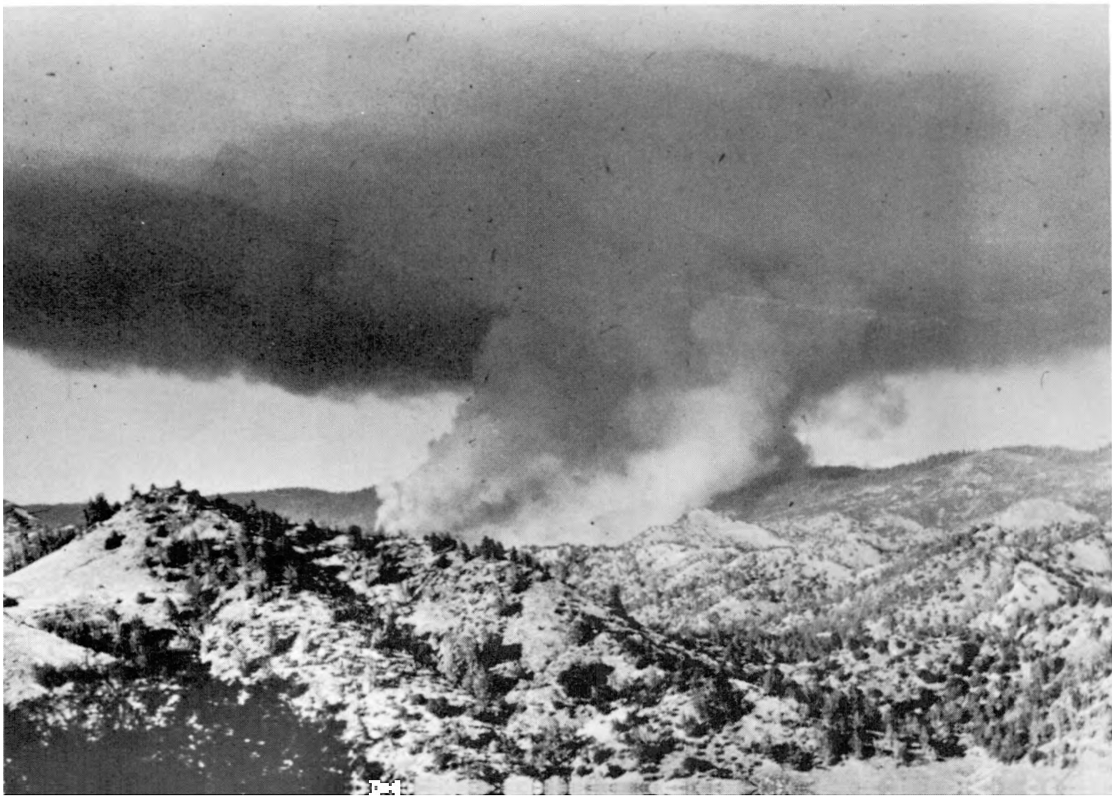


Figure 4.—Towering convection column typical of fires burning in an unstable atmosphere with light winds aloft. Jameson Fire, Cleveland National Forest, California, August 31, 1954.

Figure 5.—Flattened convection column typical of fires burning beneath an inversion. Haslett Fire, Sierra National Forest, California, October 15, 1961.



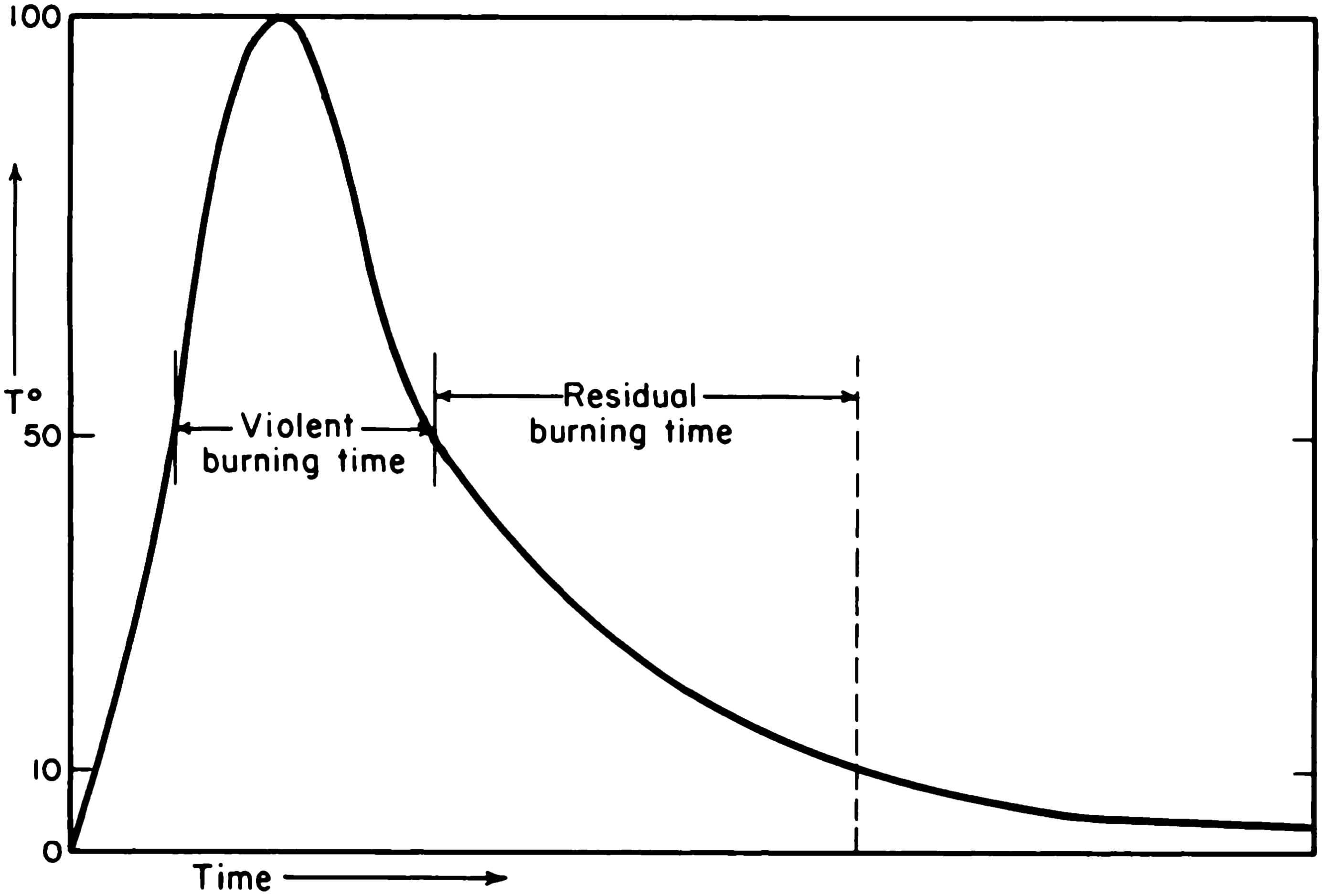


Figure 11.—Distribution of temperature in relation to burning time. T° represents percentage difference between initial temperature and maximum temperature.

Table 1. Violent and residual burning times, by fuel type

Fuel type	Violent burning		Residual burning	
	Time	Total energy release	Time	Total energy release
	Minutes	*Percent*	*Minutes*	*Percent*
Grass	1½	>90	½	<10
Light brush (12 tons/ acre)	2	60	6	40
Medium brush (25 tons/ acre)	6	50	24	50
Heavy brush (40 tons/ acre)	10	40	70	60
Timber	24	17	157	83

Since there were no data available from which to determine the total burning time, we obtained the opinions of experienced fire control personnel in various parts of the country. The consensus was as follows:

Fuel type:	*Time*
Grass	30 minutes
Light brush	16 hours
Medium brush	36 hours
Heavy brush	72 hours
Timber	7 days

'No Spread' Criteria

To prepare a mathematical model of fire spread in which firefighting effort is assumed to be ineffective, it is necessary to provide "stopping rules," that is, the burning conditions under which fires could be expected to exhibit essentially no outward spread.

Ten of the various fire danger rating systems commonly used in the United States and Canada have as the starting point for the index number system "the weather conditions such that abandoned camp fires or debris burning fires will spread sufficiently to pose a threat requiring fire control action." When we examined the weather and fuel conditions specified for this point in each of the 10 systems, we found them remarkably consistent. Accordingly, we prepared the following list of "no spread" criteria.

Large fires in the following fuel types can be expected to show no measurable spread when the following conditions are met:

All fuels: over 1 inch of snow on the ground at the nearest weather reporting stations.

Grass: relative humidity above 80 percent.

Brush or Hardwoods: 0.1 inch of precipitation or more within the past 7 days *and*—

Wind 0-3 mph; relative humidity 60 percent or higher, or

Wind 4-10 mph; relative humidity 75 percent or higher, or

Wind 11-25 mph; relative humidity 85 percent or higher.

Conifer Timber: (a) 1 day or less since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 50 percent or higher, or

Wind 4-10 mph; relative humidity 75 percent or higher, or

Wind, 11-25 mph; relative humidity 85 percent or higher.

(b) Or, 2-3 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 60 percent or higher, or

Wind 4-10 mph; relative humidity 80 percent or higher, or

Wind 11-25 mph; relative humidity 90 percent or higher.

(c) Or, 4-5 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 80 percent or higher.

(d) Or, 6-7 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 90 percent or higher.

These criteria were tested against the records of 4,378 forest fires that burned for more than an hour before firefighters arrived and for which adequate spread and weather records were available. Fires were listed as "no spread" if their rate of free spread before the arrival of firefighting forces was 0.4 chains per hour (0.005 mph) or less.

Of the 134 fires that burned under conditions in which no spread would be predicted, 131—97.8 percent—did not spread. Closer examination of the three fires that did spread showed that rain had fallen at one or two but *not* at all of the three nearest weather stations. It is possible that all three failures of prediction were due to showers that wet the weather station, but not the fire area. Thus the criteria selected appear adequate for predicting the weather conditions when fires will not spread significantly.

But 2,537—59.8 percent—of the 4,244 fires that burned when the criteria predicted "will spread" did not spread at a rate of 0.005 mph or faster.

CIVIL DEFENCE

why we need it

Message from the Home Secretary and the Secretary of State for Scotland

For over 30 years our country, with our allies, has sought to avoid war by deterring potential aggressors. Some disagree as to the means we should use. But whatever view we take, we should surely all recognise the need – and indeed the duty – to protect our civil population if an attack were to be made upon us; and therefore to prepare accordingly.

The Government is determined that United Kingdom civil defence shall go ahead. The function of civil defence is not to encourage war, or to put an acceptable face on it. It is to adapt ourselves to the reality that we at present must live with, and to prepare ourselves so that we could alleviate the suffering which war would cause if it came.

Even the strongest supporter of unilateral disarmament can consistently give equal support to civil defence, since its purpose and effect are essentially humane.

George Younger.

Why bother with civil defence?

Why bother with wearing a seat belt in a car? Because a seat belt is reckoned to lessen the chance of serious injury in a crash. The same applies to civil defence in peacetime.

War would be horrific. Everyone knows the kind of devastation and suffering it could cause. But while war is a possibility – however slight – it is right to take measures to help the victims of an attack, whether nuclear or 'conventional'.

But isn't it a waste of money in these days of nuclear weapons and the dreadful prospects of destruction?

No. It is money well spent if it shows people how they can safeguard themselves and their families.

But surely there is no real protection against a nuclear attack?

Millions of lives could be saved, by safeguards against radiation especially. But civil defence is not just protection against a nuclear attack. It is protection against *any* sort of attack. NATO experts reckon that any war involving the UK is likely at least to start with non-nuclear weapons. Indeed, while no war is likely so long as we maintain a credible deterrent, the likelihood of a nuclear war is less than that of a 'conventional' one.

But doesn't civil defence get people more war-minded, thus increasing the risk of conflict?

That is like saying people who wear seat belts are expecting to have more crashes than those who do not. Taking civil defence seriously means seeking to save lives in the catastrophe of an attack on our country.

To Sum Up

The case for civil defence stands regardless of whether a nuclear deterrent is necessary or not. Radioactive fallout is no respecter of neutrality. Even if the UK were not itself at war, we would be as powerless to prevent fallout from a nuclear explosion crossing the sea as was King Canute to stop the tide. This is why countries with a long tradition of neutrality (such as Switzerland and Sweden) are foremost in their civil defence precautions.

Civil defence is common sense

Further information:

Nuclear Weapons
ISBN 0 11 34055 X HMSO £3.50 (net)

Protect and Survive
ISBN 0 11 3407289 HMSO 50p (net)

Domestic Nuclear Shelters
ISBN 0 11 3407378 HMSO 50p (net)

Domestic Nuclear Shelters – Technical Guidance
ISBN 0 11 34073786 HMSO £5.50 (net)

Arguments Against Civil Defense and a Rebuttal

Some of the arguments made against civil defense were parodied as follows in a piece in the Harvard Crimson in 1962:

Recommendations by the Committee for a Sane Navigational Policy:

It has been brought to our attention that certain elements among the passengers and crew favor the installation of lifeboats on this ship. These elements have advanced the excuse that such action would save lives in the event of a maritime disaster such as the ship striking an iceberg. Although we share their concern, we remain unalterably opposed to any consideration of their course of action for the following reasons:

1. This program would lull you into a false sense of security.

2. It would cause undue alarm and destroy your desire to continue your voyage in this ship.

3. It demonstrates a lack of faith in our Captain.

4. The apparent security which lifeboats offer will make our navigators reckless.

5. These proposals will distract our attention from more important things, e.g., building unsinkable ships. They may even lead our builders to false economies and the building of ships which are actually unsafe.

6. In the event of being struck by an iceberg (we will never strike first) the lifeboats would certainly sink along with the ship.

7. If they do not sink, you will only be saved for a worse fate, inevitable death on the open sea.

8. If you should be washed ashore on a desert island, you could not adapt to the hostile environment and would surely die of exposure.

9. If you should be rescued by a passing vessel, you would spend a life of remorse mourning your lost loved ones.

10. The panic caused by a collision with an iceberg would destroy all semblance of civilized human behavior. We shudder at the prospect of one man shooting another for the possession of a lifeboat.

11. Such a catastrophe is too horrible to contemplate. Anyone who does contemplate it obviously advocates it.

A. R. P.

(Air Raid Precautions)

by

J. B. S. HALDANE, F.R.S.

(Co-inventor of 1915 gas masks)

SEPTEMBER
1938

LONDON
VICTOR GOLLANCZ LTD
1938

keyholes and cracks in the wall or between the floor-boards are to be filled with putty or sodden newspaper.

The windows must be specially protected against breakage by blast or splinters.

(Plastic sheets and duct tape for broken windows)

How far are these precautions effective? In 1937 a committee of the Cambridge Scientists' Anti-War Group published a book[1] in which it was stated that no ordinary room is anywhere near gas-proof.

[1] *The Protection of the Public from Aerial Attack.*

Error of Cambridge Scientists' Anti War Group:

The real criticism is as follows. It is unlikely that there would be a lethal concentration of gas out of doors for a long period. The wind carries gas away, and in cities there are vertical air currents even in calm weather. If many tons of bombs could be dropped in the same small area either at once or in succession this would not be so. But given any sort of defence bombs will be dropped more or less at random.

Suppose we had out of doors during 10 minutes a phosgene concentration of one part in 10,000, which would be fatal in a few breaths to people in the street, the concentration inside would never rise as high as $\frac{1}{15}$ of this value[1] if the leakage time were $2\frac{1}{2}$ hours, which is rather low. (Hence protection factor = 15)

[1] Since 10 minutes is $\frac{1}{15}$ of $2\frac{1}{2}$ hours.

Many of the questions which are asked concerning Air Raid Precautions are unanswerable in the form in which they are put. If I am asked "Does any gas mask give complete protection against phosgene" the only literally true answer is "No." One could not live in a room full of pure phosgene in any of them. And one would be killed if a hundred-pound phosgene bomb burst in the room, even when wearing the very best mask. But one would be safe in a phosgene concentration of one part per thousand, of which a single breath would probably kill an unprotected man. Hence in practice such a mask is a very nearly complete protection.

1. Non-persistent gases, such as phosgene. They can be dropped in bombs which burst, and suddenly let loose a cloud of gas, which is poisonous when breathed, but which gradually disperses. If there is a wind the dispersal is very quick; in calm, and especially in foggy weather, it is much slower. These gases can penetrate into houses, but very slowly. So even in a badly-constructed house one is enormously safer than in the open air. Even the cheapest type of gas mask, *provided it fits properly and is put on at once*, gives good protection against them (see Chapter IV).

2. Persistent gases, such as mustard gas. Mustard gas is the vapour of an oily liquid, which I shall call mustard liquid. So far as I know this has not been dropped from aeroplanes in bombs on any great scale. It was used very effectively by the Italians in Abyssinia, who sprayed it in a sort of rain from special sprayers attached to the wings of low-flying aeroplanes.

If the mustard liquid could be sprayed evenly, things would be far more serious. All the outside air of a large town would be poisonous for several days. But this would only be possible if the spraying aeroplanes could fly to and fro over the town in formation, and at a height of not more than 300 feet or so. A fine rain of mustard liquid would probably evaporate on its way to the ground, or blow away, if it were let loose several thousand feet up in the air. Spraying from low-flying aeroplanes was possible in Abyssinia because the Abyssinians had no anti-aircraft guns and no defensive aeroplanes. It would probably not be possible in Britain.

THE HAMBURG DISASTER. Fantastic nonsense has been talked about the possible effects of gas bombs on a town. For example, Lord Halsbury said that a single gas bomb dropped in Piccadilly Circus would kill everyone between the Thames and Regent's Park. Fortunately, although no gas bombs have been dropped in towns in war-time, there are recorded facts[1] which give us an idea of what their effect would be. On Sunday, May 20th, 1928, at about 4.15 p.m., a tank containing 11 tons of phosgene burst in the dock area of Hamburg.

Casualties occurred up to six miles away. In all 300 people were made ill enough to be taken to hospital, and of these ten died. About fifty of the rest were seriously ill. These casualties are remarkably small.

[1] Hegler, *Deutsche Medizinische Wochenschrift*, 1928, p. 1551.

WHY GAS WAS NOT USED IN SPAIN

In view of the terrible stories as to the effects of gas, many people are surprised that it has not been used in Spain. First, why was it not used against the loyalist army? Secondly, why was it not used against towns? The soldiers had respirators after about February 1937, but were not well trained in their use, and often lost them. Very few civilians had any respirators at all.

Gas was not used in the field for several reasons. The main reason is that the number of men and guns per mile was far less than on the fronts in the Great War. Gas is effective if you have a great deal of it,

but the amount needed is enormous. Thus during the night of March 10-11th, 1918, the Germans fired about 150,000 mustard-gas shells into an area of some twenty square miles south-west of Cambrai. If most of the air in a large area is poisoned the effects are serious. But if a few gas shells are fired or a few cylinders let off, the gas soon scatters and ceases to be poisonous, and a man can often run to a gas-free place, even without a mask, before he is poisoned.

Gas was not used against the towns for this reason, and for another, which is very important. Gas only leaks quite slowly into houses, particularly if there are no fires to make a draught, and draw in outside air; and there is very little fuel in loyal Spain.

PANIC

Panic can be a direct cause of death. If too many people crowd into a shelter, especially one with narrow stairs leading to it, they may easily be crushed to death. In January 1918 fourteen people were killed in this way at Bishopsgate Station in London, and sixty-six were killed in a panic in one of the Paris Underground stations as the result of a false gas alarm.

(Bishopsgate Station incident: 28 January 1918)

BACTERIA AND OTHER MICROBES

It is possible that these will be used in some kind of spray or dust. The difficulty is a technical one. It is easy to disperse many solids as smoke. But this needs heat, and cooked bacteria are harmless. Many

bacteria are killed even by drying. And once bacteria are on the ground they generally stay there. Possibly pneumonic plague or some other air-borne disease might be started by a dust-bomb. Cholera bacilli might be dropped in a reservoir. But they would probably be stopped by filters, and even without this would be likely to die before they reached the houses.

A million fleas weigh very little, and could easily be dropped. In theory they could be infected with plague. In practice this would need a staff of hundreds of trained bacteriologists, and huge laboratories. So with other possible means of infection. Some may very well be tried, if only to create a panic, but I would sooner face bacteria than bombs.

Certain pacifist writers are severely to blame for our present terror of air raids. They have given quite exaggerated accounts of what is likely to happen.

So long as civilian populations are unprotected, criminal States will continue to murder the citizens of their weaker neighbours and to blackmail the stronger.

PHYSICAL PROPERTIES OF A GAS-CLOUD. Every student of chemistry learns that a heavy gas such as chlorine can be poured from one vessel into another almost like water, whilst a light gas such as hydrogen rapidly rises. Now all the poisonous gases and vapours used in war are heavier than air, so it is thought that they would inevitably flood cellars and underground shelters, and that on the first floor of a house one would not be safe.

But within a short time it would be mixed with many times its volume of air. Now air containing one part in 10,000 of phosgene is extremely poisonous. But its density exceeds that of air by only one part in 4,000.

GAS-MASKS, AND GAS-PROOF BAGS FOR BABIES

THE EARLIEST GAS-MASKS made in 1915, relied on chemical means to stop chlorine, which was the first gas used. A cloth soaked with sodium phenate or various other compounds will stop chlorine on its way through. But it would not stop carbon monoxide, mustard gas, or many other gases. The terrible prospect arose that it would be necessary to devise a new chemical to stop each new gas. There would be a continual series of surprise attacks with different gases, each successful until a remedy was found, and each involving the death of thousands of men.

It is a most fortunate fact that the majority of vapours can be removed from air, not by chemical combination, but by a process called adsorption, which is non-specific. For example lime will stop an acid gas such as carbon dioxide, and woollen cloth soaked in acid will stop an alkaline gas such as ammonia. No single chemical will combine with both.

But charcoal, silica, and various other substances, when properly prepared, will take up vapours of different chemical types. The molecules form a very thin liquid layer on the surface of the adsorbent, as indeed they do on glass or metals. But charcoal is full of pores and has an enormous surface per unit of weight; so it can take up a great deal of gas.

The main characteristic in a vapour which renders it adsorbable is that it should be the vapour of a liquid with a high boiling point. Thus carbon monoxide boils at–190° C, and is hardly adsorbed at all. Phosgene boils at 8° C and is fairly easily adsorbed. Mustard gas boils at 217° C and is very easily adsorbed indeed. This has a lucky consequence. It is quite sure that there are no unknown poisonous gases with a boiling point as low as that of carbon monoxide. For only a substance with very small molecules can have so low a boiling point. And chemists have made all the possible types of very small molecules. It is unlikely that there are any unknown poisonous gases with as low a boiling point as phosgene, though it is just possible. But if there are they will probably be stopped by charcoal. There may very possibly be some vapours of high boiling point more poisonous than mustard gas. But if so I am prepared to bet a thousand to one that charcoal will stop them all.

FINAL REPORT

11 March 1963

Recovery and Decontamination
Measures after
Biological and Chemical Attack

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

Contract OCD-OS-62-183

Prepared for
Office of Civil Defense
Department of Defense

by

Science Communication, Inc.
1079 Wisconsin Avenue, N.W.
Washington 7, D. C.

To plan for countermeasures against any weapons one must understand the problem—the nature, the potentials, and the limitations. This research project and the resultant final report were intended to bring together current information most applicable to civil defense. It was particularly intended for those who are responsible for planning preparatory, reclamation and countermeasures effort to minimize the damage from a BW/CW attack.

William J. Lacy
Project Coordinator
Postattack Research

Decontaminants

An important class of decontaminants comprises the common substances or natural influences such as time, air, earth, water, and fire.

Natural Effects

Biological agents are living organisms and tend to die off with time unless they are in a favorable environment with moisture, food, warmth, and other factors necessary for their survival. In addition, most biological organisms are very sensitive to the conditions of temperature and humidity -- and, particularly to the ultra-violet portion of sunlight. Adverse exposure to the elements -- air, sunlight, high temperature, low humidity -- is effective, in fact, against all biological agents except the spore forms of bacterial organisms.

It is generally assumed that in the vegetative form bacteria (as contrasted to the spore form) can persist for less than two hours during daytime and about eighteen hours at night. Since these short-lived bacteria are the most probable agents, outdoor decontamination is usually not called for unless the agent has been identified, either by laboratory tests or by the character of the disease, as one which forms spores or is otherwise known to be persistent.

The persistent, low-volatile, agents such as the liquid nerve agents (V-agents) and the blister gases present the principal chemical decontamination problem. Even these evaporate in time. The speed of evaporation and dissipation is enhanced by higher temperatures and wind. Thus, if it is possible to avoid the area or the use of contaminated objects for a reasonable length of time, decontamination may be unnecessary. Such periods might run from hours to a few days, depending on the degree of contamination and weather conditions. In cold weather the agents will persist for longer periods.

Water

Next to weathering, the most important natural decontaminant is water, used either to remove the agent, with or without soap or detergents to assist, or by boiling. One caution -- water used to wash away contamination becomes contaminated and must be disposed of accordingly. Boiling destroys most chemical agents and all biological agents. When it is feasible, boiling is one of the most generally desirable methods -- particularly for household use by individuals.

Earth and fire, the other natural decontaminants, would have relatively little application in civil defense BW/CW decontamination operations. Earth may be used to cover contamination temporarily to keep it out of contact with people while natural processes either dissipate or destroy the agent. This involves substantial effort with bulldozers and earth-moving equipment and usually is neither practical or necessary.

Chemical Decontaminants

These are preferred when they are available. Chemical decontaminants fall in two classes -- those which destroy or neutralize the agents, and those which simply assist in their removal.

The principal decontaminants which destroy or neutralize are:

- Chlorine-containing materials, such as calcium hypochlorite (HTH) and sodium hypochlorite solutions. Many household disinfectants available under various brand names -- Clorox, Purex, etc. -- are sodium hypochlorite solutions.
- Alkalies, such as caustic soda (lye) and sodium carbonate (washing soda, or soda ash).

The chlorine-containing materials, in proper concentrations, are effective against both biological and chemical agents. As solutions they are used to decontaminate surfaces, as in washing off sealed food containers; for decontaminating cotton fabrics by soaking or addition during the washing process; and for sterilizing water. Hypochlorite solutions have the disadvantage of corroding metals and so must be rinsed off thoroughly.

The hypochlorites -- calcium and sodium -- are the preferred decontaminants for blister gases and liquid nerve agents. For most such applications they are used as solutions but for vertical surfaces or porous surfaces a "whitewash" of calcium hypochlorite (HTH), hydrated lime, and water (called a "slurry") is more effective

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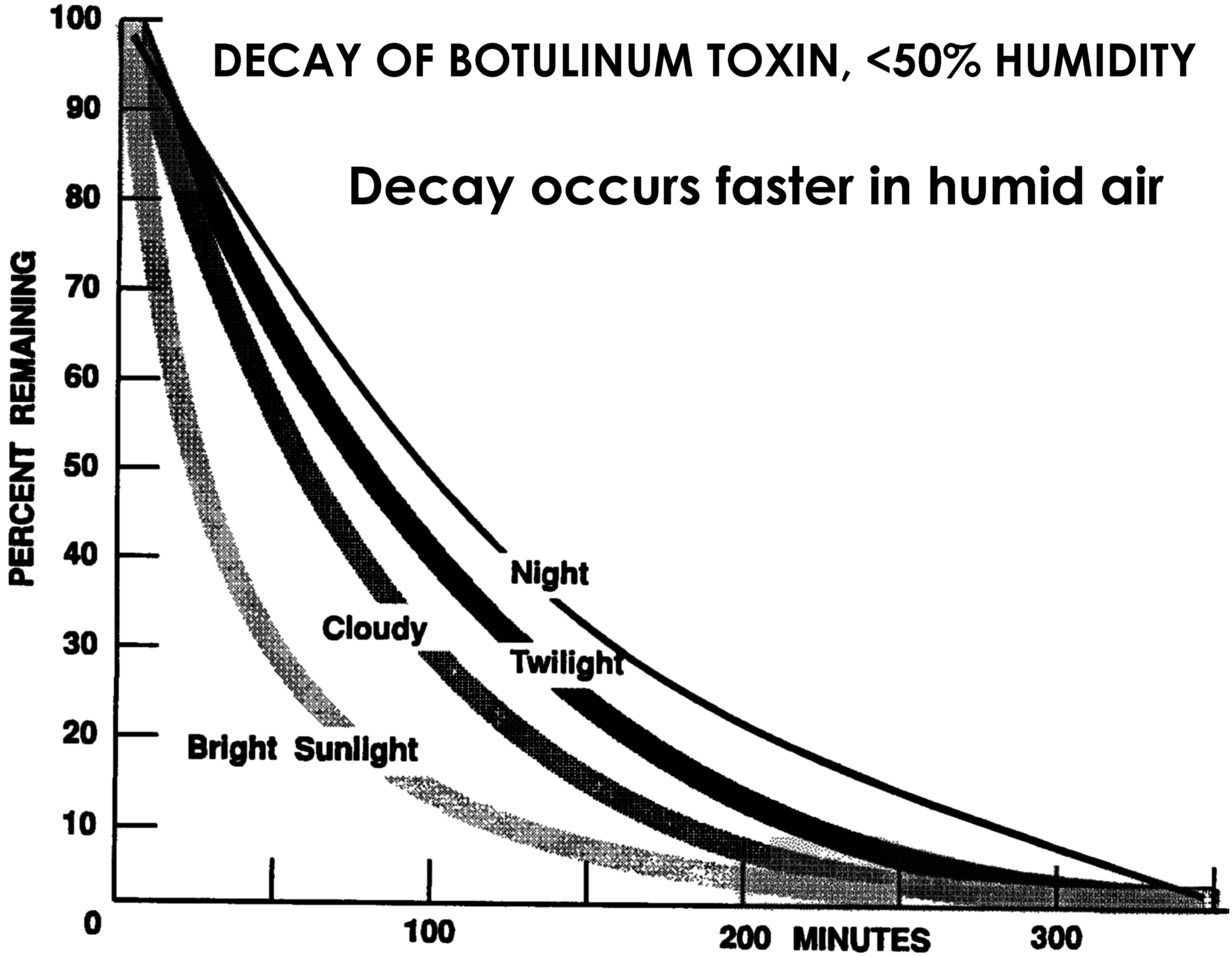
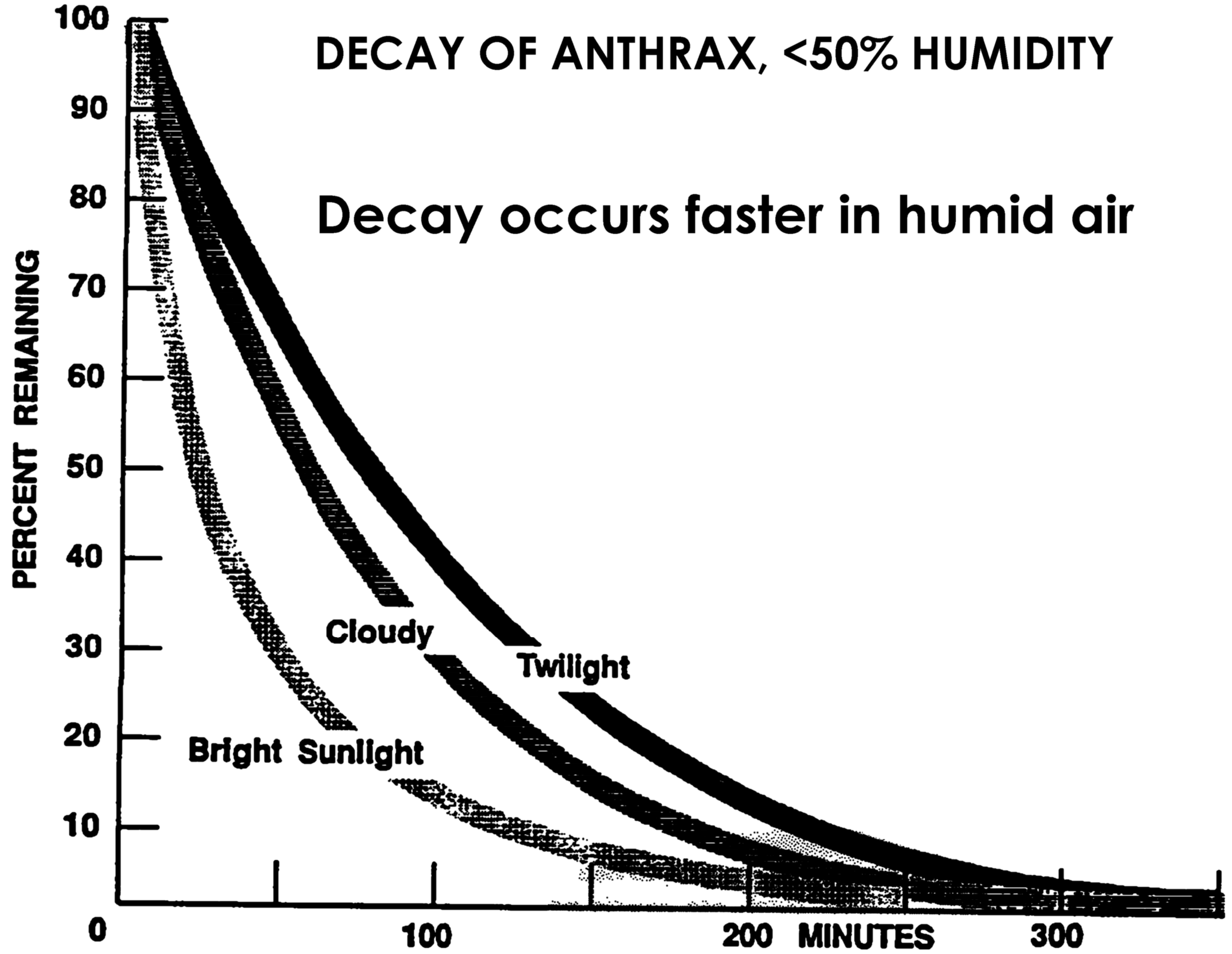


U.S. Army Field Manual FM 3-3 (1992), Fig. B-3.



U.S. Army Field Manual FM 3-3 (1992), Fig. B-1.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature		GA/ GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
C°	F°					
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE
1 For grassy terrain multiply the number in the chart by 0.4.
2 For grassy terrain multiply the number in the chart by 1.75.
3 For sandy terrain multiply the number in the chart by 4.5.
* Agent persistency time is less than 1 hour.
** Agent is in a frozen state and will not evaporate or decay.
*** Agent persistency time exceeds 2,000 hours.

COMPARATIVE VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Volatility (mg/m^3) at 25°C
Hydrogen cyanide (HCN)	1,000,000
Sarin (GB)	22,000
Soman (GD)	3,900
Sulfur mustard	900
Tabun (GA)	610
Cyclosarin (GF)	580
VX	10
VR (“Russian VX”)	9

Data source: US Departments of the Army, Navy, and Air Force. *Potential Military Chemical/Biological Agents and Compounds*. Washington, DC: Headquarters, DA, DN, DAF; December 12, 1990. Field Manual 3-9. Naval Facility Command P-467. Air Force Regulation 355-7.

SIGNS AND SYMPTOMS REPORTED BY TOKYO HOSPITAL WORKERS TREATING VICTIMS OF SARIN SUBWAY ATTACKS*

Symptom	Number/percentage of the 15 physicians who treated patients at UH		Number/percentage of 472 care providers reporting symptoms at SLI	
Dim vision	11	73%	66	14%
Rhinorrhea	8	53%	No information	
Dyspnea (chest tightness)	4	27%	25	5.3%
Cough	2	13%	No information	
Headache	No information		52	11%
Throat pain	No information		39	8.3%
Nausea	No information		14	3.0%
Dizziness	No information		12	2.5%
Nose pain	No information		6	1.9%

*Data reflect reported survey of self-reported symptomatology of physicians at the University Hospital of Metropolitan Japan emergency department and all hospital workers at Saint Luke's International Hospital exposed to sarin vapors from victims of the Tokyo subway attack.

SLI: Saint Luke's International Hospital

UH: University Hospital

Data sources: (1) Nozaki H, Hori S, Shinozawa Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21:1032-1035. (2) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 1: community emergency response. *Acad Emerg Med.* 1998;5:613-617. (3) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 2: Hospital response. *Acad Emerg Med.* 1998;5:618-624.

TABLE 21-3

MANAGEMENT OF MILD TO MODERATE NERVE AGENT EXPOSURES

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	**Symptoms**	**Age**	**Dose**	**Age**	**Dose**
• Tabun • Sarin • Cyclosarin • Soman • VX	• Localized sweating • Muscle fasciculations • Nausea • Vomiting • Weakness/floppiness • Dyspnea • Constricted pupils and blurred vision • Rhinorrhea • Excessive tears • Excessive salivation • Chest tightness • Stomach cramps • Tachycardia or bradycardia	Neonates and infants up to 6 months old	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.25 mg AtroPen† and **2-PAM** 15 mg/kg IM or IV slowly to max 2 g/hr	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.5 mg AtroPen and **2-PAM** 25 mg/kg IM or IV slowly to max 2 g/hr	Young children (30 days old–5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 1 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Children (≥ 5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 10 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 2 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8 hr period or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

2-PAM: 2-pralidoxime
IM: intramuscular
IO: intraosseous
IV: intraveneous
PDH: Pediatrics Dosage Handbook
*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 minutes until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible.
†Meridian Medical Technologies Inc, Bristol, Tenn.
Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtropPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio; Lexi-Comp Inc: 2006.

TABLE 21-4

MANAGEMENT OF SEVERE NERVE AGENT EXPOSURE

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	Severe Symptoms	Age	Dose	Age	Dose
• Tabun • Sarin • Cyclosarin • Soman • VX	• Convulsions • Loss of consciousness • Apnea • Flaccid paralysis • Cardio-pulmonary arrest • Strange and confused behavior • Severe difficulty breathing • Involuntary urination and defecation	Neonates and infants up to 6 months old	**Atropine** 0.1 mg/kg IM/IV/IO or 3 doses of 0.25mg AtroPen† (administer in rapid succession) and **2-PAM** 25 mg/kg IM or IV slowly, or 1 Mark I† kit (atropine and 2-PAM) if no other options exist	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 0.5mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, or 1 Mark I kit (atropine and 2-PAM) if no other options exist	Young children (30 days old–5 yrs and adults	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 1mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, 1 Mark I kit (atropine and 2-PAM) up to age 7, 2 Mark I kits for ages > 7–10 yrs	Children (≥ 5 yrs old)	**Diazepam** 0.05-0.3 mg/kg IV to a max of 10 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 6 mg IM or 3 doses of 2 mg AtroPen (administer in rapid succession) and **2-PAM** 1800 mg IV/IM/IO, or 2 Mark I kits (atropine and 2-PAM) up to age 14, 3 Mark I kits for ages ≥ 14 yrs	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8-hr period, or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

IM: intramuscular
IO: intraosseous
IV: intravenous

*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 min until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible. †Meridian Medical Technologies Inc, Bristol, Tenn.

Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtroPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio: Lexi-Comp Inc; 2006.

A PENGUIN SPECIAL

C. E. M. JOAD

Why War?

"My case is that war is not something that is inevitable, but is the result of certain man-made circumstances; that man can abolish them, as he abolished the circumstances in which the plague flourished."

NEW REVISED EDITION

C. E. M. Joad

C. E. M. Joad, M.A., D.Lit., was born in 1891, educated at Blundell's School, Tiverton, and Balliol College, Oxford, and entered the Civil Service in August 1914. He was in the Ministry of Labour from 1914 to 1930. He then resigned and became Head of the Department of Philosophy and Psychology at Birkbeck College, University of London. He is the author of numerous original books of philosophy, having chiefly established his reputation as an interpreter of philosophy for the general public. His *Guide to Philosophy*, published in 1936, has been reprinted nine times. Is also the author of two unusual autobiographical books, the *Book of Joad* and the *Testament of Joad*. Finally, he is well known as a pacifist.

He is a keen rider, a great walker, plays hockey and tennis.

WHY WAR?

by

C. E. M. JOAD

AUTHOR OF

Guide to Philosophy
Guide to the Philosophy of Morals and Politics
The Book of Joad
Guide to Modern Thought, etc.

(NOTE THAT CYRIL JOAD LED THE 9 February 1933 OXFORD UNION "KING AND COUNTRY" PACIFISM.)

First published 1939
Reprinted September 1939

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Mr. Churchill and Sir Norman Angell.

The process, it is obvious, is not one that makes for security. One does not, if one is wise, insure oneself against fire by devoting all one's savings to the storing up of explosives. Apart from the vested interest in war of the armament makers, the professional interest in war of young men trained in the use of modern weapons and anxious to exhibit their technical skill, is it not obvious that those nations which possess great armaments will, sooner or later, use them as surely as children will use elaborate and exciting toys? The most convincing comment that I have heard on the whole lunatic business was made at a meeting which I attended as an undergraduate at Oxford in the year before the war. The meeting was addressed by a Cabinet Minister. "There is," he said, "just one way in which you can make your country secure and have peace, and that is to be so much stronger than any prospective enemy that he dare not attack you, and this is, I submit to you, gentlemen, a self-evident proposition." A small man got up at the back of the hall and asked him whether the advice he had just given was the advice he would give to Germany. A faint titter ran through the meeting——the audience was, I suppose, above the average in political intelligence—but there was no applause. Presently, the time came for speeches by the audience. In a speech equally devastating to the Cabinet Minister, and convincing to me, the questioner proceeded to drive home the moral which his question had implied. "Here," he pointed out, "are two nations or groups of nations likely to quarrel. How shall each be secure and keep

the peace? Our Cabinet Minister tells us in the profundity of his wisdom, that both will be secure, both will keep the peace when each is stronger than the other. And this, he thinks, is a self-evident proposition." This time there was loud applause. It remains to add that the Cabinet Minister was Winston Churchill, his questioner Sir Norman Angell.

(IMPLICITLY ASSUMES BOTH SIDES TO BE EQUIVALENT MORALLY AND IN ECONOMIC VIABILITY. ACTUALLY, DICTATORSHIPS ARE NOT AS VIABLE IN AN ARMS RACE, BECAUSE OF CENTRALIZED, MONOLITHIC CONTROL WHICH IS SHORT-SIGHTED AND FAILS TO INSPIRE AND MOTIVATE PEOPLE IN THE LONG TERM LIKE CAPITALISM)

(NOTE ALSO THAT SIR NORMAN ANGELL AUTHORED THE 1909 PACIFIST BOOK "THE GREAT ILLUSION", CLAIMING THAT SINCE WARS ARE EXPENSIVE THEY ARE A FINANCIAL ILLUSION.)

(GERMANY TOOK NO NOTICE OF ANGELL IN 1914/1939, BUT APPEASERS DID!)

at some future date. "Standing up" to Hitler means being prepared to fight a war whose object would, presumably, be to preserve liberty and democracy, to overthrow Fascism and—we must, I suppose, add—to lay the foundations of a lasting peace. History, as I have tried to show, affords no warrant for supposing that the war would have any such results. But while it is impossible to predict the *ultimate* results of a modern war, those which seem reasonably probable include the destruction of most of what goes by the name of civilization in the contemporary world. **VAGUE!**

EXAGGERATIONS OF BOMBING EFFECTS:

The Character of the Next War.

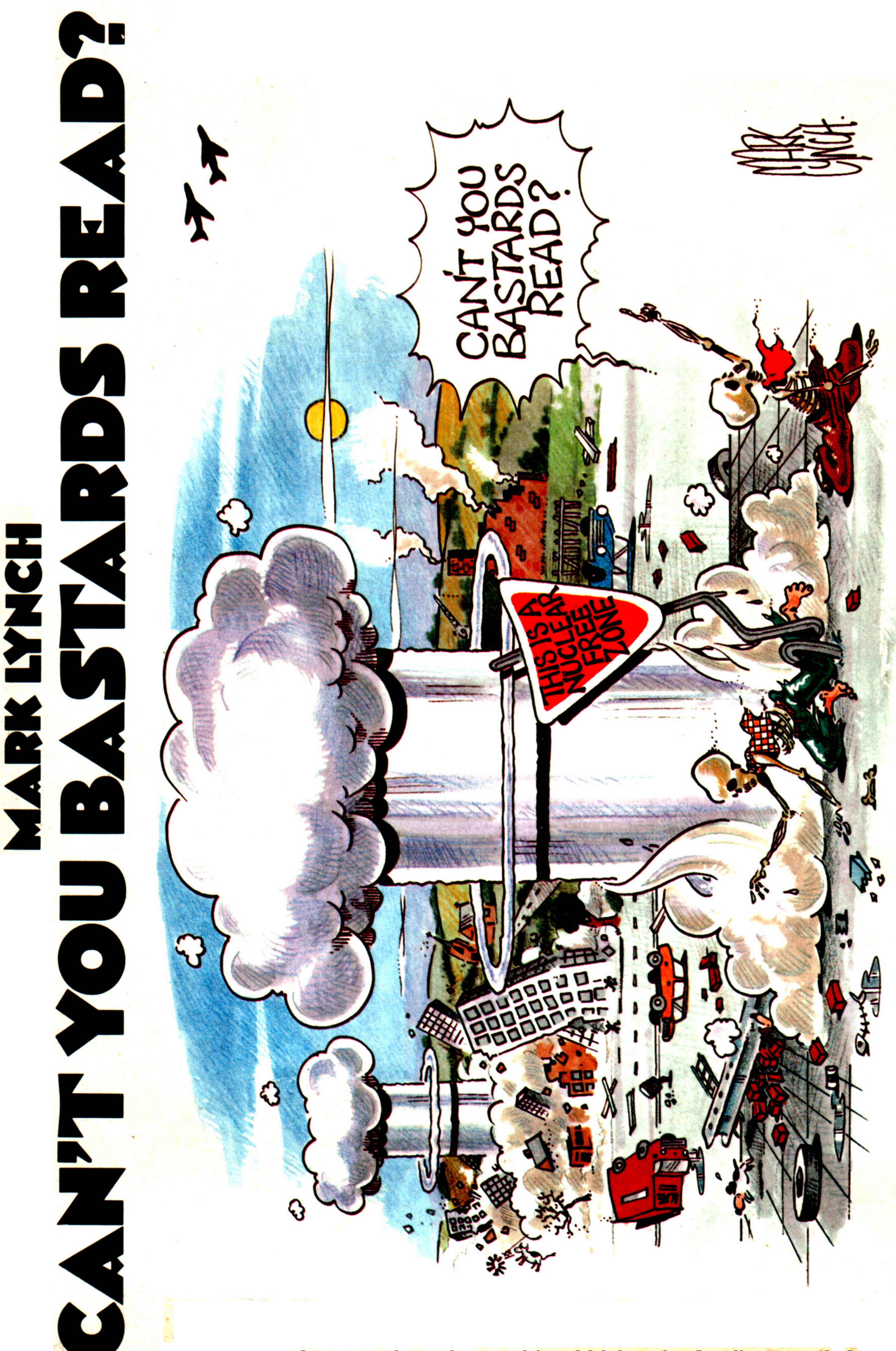
The horrors with which the invention of the bombing aeroplane has invested war are by now familiar, but few of us, in spite of the crisis through which we lived in September, 1938, have any conception of the nature and effects of the large-scale bombing of London. It is not merely that gas and explosive bombs will kill civilians and destroy houses; it is not merely the horror of the direct hit upon the hospital full of wounded, or of the thermite bomb that sets fire to the asylum. Scarcely less harrowing, though I think, less generally regarded, is the prospect of the destruction of the lighting and heating systems of London with the resultant dark streets and unwarmed houses, of the ventilating apparatus that operates in the tubes by the bombing of the power stations with the resultant suffocation of those who have taken refuge in the tunnels, of the smashing of the drains to let loose into the streets their burden of sewage laden with the germs of disease to complete the destruction wrought by men, of the jamming of the roads leading from London to the country by hordes of panic-stricken fugitives, fleeing from the terror in the air, without petrol for their cars, without food, without shelter, of the crowds of starving men

who, presently, will spread over the countryside, looting and plundering. . . . I have read a number of books on this subject and the weight of opinion seems to be decisively in favour of the view that whatever protection we may devise for civilians, we cannot preserve the fabric of the civilization in which we live. Water, gas and light mains, sewers, roads, transport offices, factories, homes, railway stations, telephone exchanges, standing crops, cattle—all are vulnerable.

We must, then, it is clear, face the possibility of the breakdown of the social services, the cutting of the nerves which keep our social system alive, and the relapse of society into a chaos of panic-stricken individuals fighting each for his own hand, save on one condition, the establishment of a military dictatorship which imposes upon the country an iron discipline, suppresses the right of criticism, stifles grievances and shoots grumblers and dissidents at sight. Such is the most probable result of a war fought under modern conditions for idealistic ends. In a word, all the liberties that we now cherish and would be fighting to preserve would disappear. Through sheer pressure of circumstances, the war to save democracy would kill democracy within twenty-four hours of its declaration.

Gangsters and Troglodytes.

There is one further possibility. If, as may well be the case, the next war, or the next war but one, brings about the destruction of our civilization, it will be succeeded by a series of governments of the gangster type envisaged in Mr. Wells's *Shape of Things to Come*. In a half-starved world gangs will fight for food and plunder, and the most successful will become the government. What sort of end is this to a war for liberty, for democracy, and for civilization? And what sort of life will our descendants be living after a series of such wars?



(cover of Mark Lynch's 1988 book, Grafton Books)

HISTORY OF THE SECOND WORLD WAR

Civil Defence

By

T. H. O'BRIEN

CIVIL DEFENCE

BY

TERENCE H. O'BRIEN

LONDON: 1955

HER MAJESTY'S STATIONERY OFFICE

AND

LONGMANS, GREEN AND CO

The point is of importance for students of the subject in an era in which marked 'progress' has been made in the technique of air warfare by the invention of the atomic bomb. This invention has given fresh currency to the view that 'nowadays every war is different from the one before'—which, if it were valid, would abolish any need to learn the lessons of past experience.

But in May 1917 the Germans began a series of assaults with twin-engined aircraft, called *Gothas*, which soon became severe. The daylight attack of 13th June on London by fourteen *Gothas* was the worst single attack of the war measured in casualties, which numbered 162 killed and 426 injured; 118 high explosive and incendiary bombs were dropped on the City and the East End.

The Government only gave in gradually and reluctantly to demands for public warnings in London. In July 1917 a system was introduced, under the control of the Commissioner of Police, which to those accustomed to the sirens of 1939–45 may appear somewhat primitive. Warnings were distributed partly by maroons (or sound bombs) fired into the air, and partly by policemen on foot, on bicycles or in cars carrying *Take Cover* placards and blowing whistles or sounding horns.

during 1914–18 There were in all 103 bombing raids (51 by airships and 52 by aeroplanes); and about 300 tons of bombs were dropped causing 4,820 casualties, 1,413 of which were fatal.

These totals appear small; but when they are broken down into details many different pictures emerge. The two heavy raids on London of June and July 1917, for example, together caused 832 casualties (216 fatal), which amounted to 121 casualties for each ton of bombs dropped; and these casualty figures were to have much significance for the planning authorities of the future.

13 June London raid: 118 bombs, 162 killed, 426 injured.
7 July London raid: 54 killed, 190 injured

121 casualties/ton, 31 killed/ton
(Air raids by twin-engined Gothas began in May 1917)

The Committee of Imperial Defence, created in 1904

In November 1921 the Committee asked the principal Service experts to report on the problem of possible future air attack on the United Kingdom. This report, which appeared the next year, accepted the conclusions of the Air Staff about future air attack, which were briefly as follows.

France's Air Force could drop an average weight of 1,500 tons of bombs on Britain each month by using only twenty bombing days in the month and only fifty per cent of its aircraft. London, which would be an enemy's chief objective, could be bombed on the scale of about 150 tons in the first 24 hours, 110 tons in the second 24 hours, and 75 tons in each succeeding 24 hours for an indefinite period. It was to be anticipated that an enemy would put forth his maximum strength at the outset.

Page 14: on 15 May 1924, the Air Raid Precautions (ARP) Sub-Committee first met, chaired by Sir John Anderson.

The serious picture thus presented assumed its darkest tones when the Air Staff proceeded to estimate casualties. The 300 tons of bombs dropped in the 1914–18 attacks, the experts pointed out, had caused 4,820 casualties, or 16 per ton of bombs. The 832 casualties of the two big daylight attacks on London in the summer of 1917, however,

produced an average of 121 casualties per ton; and sixteen night raids on London in 1917–18 gave an average of 52 casualties per ton.[1] After weighting these figures with various factors, the experts concluded that 50 casualties (one-third of which would be fatal) per ton formed a reasonable estimate of casualties caused by air attacks of the future on densely-populated areas. For other areas this figure should be reduced in proportion to the actual density of population.

In March 1927 the committee was faced with two matters

Royal Charter incorporating the British Broadcasting Corporation, *Wireless Broadcasting*, Cmd. 2756, 1926.

The Chemical Warfare Research Department had been making experiments to determine how long persons could remain under certain conditions in a 'gas-proof' room; and had prepared a handbook, *The Medical Aspects of Chemical Warfare*, now on sale to the public.

The first of the matters just referred to was a broadcast in February by Professor Noel Baker, on 'Foreign Affairs and How They Affect Us'. This, read in cold print at a distance of twenty years, appears as an attempt to rouse the British public to realisation of the horrors of future war, and to enlist its support for the disarmament negotiations at Geneva. The Professor quoted Mr Baldwin's speech to the Classical Association in the Middle Temple hall, 'Who in Europe does not know that one more war in the West and the civilisation of the ages will fall with as great a shock as that of Rome?' He painted a picture of gas attack from the air in another war and claimed, 'all gas experts are agreed that it would be impossible to devise means to protect the civil population from this form of attack'. The Chemical Warfare Research Department emphatically disputed the accuracy both of the details of the picture and of this general statement. They considered it unfortunate that statements of this nature should have been broadcast to the public, particularly after the Cabinet's decision that the time was not ripe for education of the public in defensive measures.

The committee discussed whether to draw the B.B.C.'s attention to this talk. The Corporation, only a few months old, was then prohibited by the Postmaster-General's instructions from broadcasting 'matter on topics of political, religious or industrial controversy'; but the Post Office representative pointed out this did not mean that his Department was prepared to undertake censoring programmes. The committee, not wishing to incur the obligation to approve in advance all proposed broadcasts relating to their field of study, decided to take no action with respect to the talk in question.

Gas was the risk most prominently associated in the public mind with future air attack, as was demonstrated a few weeks before the school opened by British reaction to Italy's use of mustard and other gases against Abyssinia.[4]

[4] According to the *Annual Register, 1936* (p. 27), 'feeling in England could hardly contain itself when the Italians were reported to be using poison gas against both soldiers and civilians'.

A final matter which concerned gas-masks belongs perhaps more properly to the topic of public reactions to A.R.P. Early in 1937 some scientific workers at Cambridge University, who described themselves as the 'Cambridge Scientists' Anti-War Group' and their function as that of acting as 'a technical and advisory body to national and international peace movements', published a book attacking the Government's A.R.P. plans.[1] This body had studied the official advice about the 'gas-proofing' of rooms, the civilian mask, and extinguishing incendiary bombs, and then conducted some experiments. It claimed to have shown that the measures officially proposed were ineffective or inadequate, and implied that these constituted deception of the public.

It has been noticed that as 1937 opened the Government was taking steps to make A.R.P. plans more widely known to the public;[2] and this deliberate challenge found a sympathetic echo in various quarters, and caused it some concern. Questions about the Cambridge experiments were asked in Parliament, for example on the occasion of the announcement of the new Wardens' Service; sections of the Press began a critical campaign, and questions were put to officials trying to build up A.R.P. services over the country. The Government's reply was that the experiments were academic (in the sense of removed from reality), and based on fallacious assumptions about the conditions likely to be met in actual warfare.[3] In spite of pressure the authorities refused to engage in technical controversy with the scientists in question and within a few months the agitation subsided. At the close of the year, however, a report on the official experiments (in supervision of which the Chemical Defence Committee had been helped by eminent scientists not in Government employment) was circulated to local authorities and otherwise made public.

[1] *The Protection of the Public from Aerial Attack* (Left Book Club Topical Book, Victor Gollancz Ltd, 1937.)

[2] p. 71.

[3] H. of C. Deb., Vol. 320, Col. 1348, 18th February 1937.

A demonstration of how to deal with the light incendiary bomb had been included in the Anti-Gas School curriculum in November 1936; and in February 1937 the Home Office Fire Adviser staged a demonstration at Barnes at which bombs were successfully controlled and fires extinguished by teams of girls with only short training. At an exercise held later at Southampton a group of air raid wardens carried out this function with such success that the Department concluded it must aim to train all householders in the handling of incendiary bombs.

Air Staff had raised their estimate of the weight of bombs which an enemy (now Germany) might drop on Britain during the first stages of an attack from 150 tons *per diem* to no less than 600 tons. The committee proceeded, as their predecessor of 1924 had done, to question the experts and then to accept their hypothesis.[1] The estimate of over 600 tons of bombs *per diem* during the first few weeks (which took account of Britain's various potential forms of counter-offensive) also embraced the possibility of a special bombing effort on the part of the enemy in the first 24 hours which might amount to 3,500 tons. Consideration had to be taken not only of this greatly increased weight of attack but of new methods of attack for which past experience afforded no precedents. The measure offered by the accepted air raid casualty figure of 1914–18 (50 per ton of bombs, 17 of which were killed and 33 wounded) was subject to the *caveat* that modern bombs were more effective. The committee pointed out that an arithmetical computation on this basis for the scale of attack at 600 tons *per diem* would indicate casualties of the order of 200,000 a week, of which 66,000 would be killed.

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[1] The new estimated scale of attack had been referred to the Home Defence Committee, and was not approved by the Committee of Imperial Defence until 28th October 1937.

The 25 million civilian gas-masks accumulated by the opening of 1938 were, from various points of view, one of the most tangible assets of the A.R.P. Service.

The invention of a practical household shelter—to be quickly known as the 'Anderson'—had transformed the possibilities hitherto envisaged for protection of homes against air attack. The Government had undertaken to supply these shelters, as well as steel fittings for strengthening basements, free to some 2½ million families.

The 'Anderson' had originally been conceived as a shelter to be erected inside the average small working-class home. But the experts soon discarded this idea as open to various objections, including the probability that occupants would be trapped by the fall of their house and killed by fire or escaping coal-gas. During Munich householders had been advised to dig trenches in their yards or gardens, and now, by an extension of this plan, the 'Anderson' was designed as an outdoor or surface shelter. It consisted of fourteen corrugated steel sheets weighing, with other components, about 8 cwt. A corrugated steel hood, curved for greater strength, would be sunk some two feet in the ground and covered with earth or sandbags.

196 *Ch. V: THE NEW ARM OF CIVIL DEFENCE*

The programme for manufacture and distribution by the end of 1939–40 of 2½ million 'Andersons' to protect about 10 million citizens was being steadily carried through.

SHELTERS 371

householders in May in the form of a booklet, *Your Home as an Air Raid Shelter*.[1] This stated that an ordinary soundly-built house would offer very substantial protection; and it gave those unable to build some form of shelter much detailed guidance on the preparation of refuge rooms, the protection of windows and so on.

[1] H.S.C. 98/40, 22nd May 1940.

416 *Ch. X: THE TIDES OF BATTLE*

16 April 1941: heaviest London air raid of WWII:

On the night of 16th-17th some 450 aircraft made the heaviest raid so far on the capital, dropping 446 tons of high explosive and 150 tons of incendiaries and causing more casualties—about 1,180 killed and 2,230 badly injured—than in any previous attack.[1] Over 2,250 fires were started; and the centre and south of the metropolis bore the brunt of the attack.

[1] German records show the much higher figures of 685 aircraft, 890 tons of H.E. and 4,200 incendiary canisters dropped. This attack proved the worst on London of the war in terms of weight of bombs dropped, casualties inflicted and the number of fires caused.

438 *Ch. X: THE TIDES OF BATTLE* **1943:**

These occasions apart, the attack was predominantly of the tip and run or—as it was sometimes called—'the scalded cat' variety. The worst single incident of the year took place on 3rd March at Bethnal Green Tube shelter when, ironically enough, no attack was in progress on this particular area. A night attack of moderate proportions was being made on London, and warnings had sounded. A woman among the crowd entering this shelter, encumbered by a baby and a bundle, fell, causing those pressing behind her to tumble in a heap and the death by suffocation of no less than 178 persons. **3 March 1943**

508 *Ch. XII: SHELTERS*

In London a periodical count was made of shelterers, usually once a month; but this took place on a single night which was not necessarily typical. In addition, the population was continually fluctuating owing to evacuation, the call-up to the Forces and war damage. The first shelter census in Metropolitan London, taken early in November 1940, showed that 9 per cent. of the estimated population spent the night in public shelters, 4 per cent. in the Tubes and 27 per cent. in household shelters—in all, only 40 per cent. in any kinds of official shelter. In September and October this proportion was probably a good deal higher. Later, as the London public became accustomed to raids, the figures dropped.

Experience of raids also led to the introduction of an entirely new type of household shelter. 'Andersons', though structurally satisfactory, had not originally been intended for sleeping and became in many cases unfit for winter occupation. Domestic surface shelters were very cramped when used for sleeping and were in some places not popular, and strengthened domestic basements had been neither very successful nor widely used. After night raiding had ceased to be a novelty, many people preferred to stay in their houses rather than to go out of doors even to their own domestic shelters. The 'Anderson', it will be recalled, had at first been envisaged as an indoor shelter. Since many people were now determined to remain in their homes, it had become necessary to introduce some indoor shelter which might reduce the risk of injury from falling masonry and furniture. The fact that many who had hitherto sheltered under their staircases or furniture had been rescued unhurt from the wreckage of houses suggested that extra protection might be given by a light structure on the ground floor.

By the end of 1940 two designs had been produced. The first, later known as the 'Morrison' shelter, had a rectangular steel framework 6 ft. 6 in. long, 4 ft. wide and about 2 ft. 9 in. high. The sides were filled in with wire mesh, the bottom consisted of a steel mattress and the top was made of steel plate an eighth of an inch thick, fastened to the framework by bolts strong enough to withstand a heavy swinging blow. The shelter, which could be used as a table in the daytime, could accommodate two adults and either two young children or one older child, lying down. Experiments showed that it would carry the debris produced by the collapse of two higher floors.

The Prime Minister showed great interest in these shelters the first of which, in fact, were erected in No. 10 Downing Street.[2] In January 1941 the Cabinet approved the manufacture of 400,000, providing protection for perhaps 1,200,000 people.[3]

In February contracts had been placed for 270,000 shelters, and another order for the same number was placed in April (thus exceeding the 400,000 originally approved). Two further orders for 270,000 were placed at the end of July and the end of September.

---

[1] Instructions were given in a pamphlet, *How to put up your Morrison shelter*, on sale to the public.

[2] One with a flat top and one with a curved top were erected in No. 10 Downing Street. The Prime Minister was at first inclined to favour the curved design but he afterwards recognised the advantages of the flat top, which would allow the shelter to be used as a table, and gave his approval to both designs.

[3] It was estimated that each 'Morrison' would use over 3 cwt. of steel, and that about 65,000 tons would be needed for the 400,000 shelters. This proved to be an underestimate since the table shelter, as finally designed, actually weighed 4.43 cwt.

In June a revised version of *Your Home as an Air Raid Shelter* was issued with the title *Shelter at Home*. This included information about three types of shelter which could be put inside refuge rooms—the 'Morrison', a commercially made steel shelter, and a timber-framed structure designed by the Ministry of Home Security.

It was assumed that to be effective in attacks by pilotless aircraft or long-range rockets, shelters would have to be easily accessible. Yet a review of London shelter in the summer of 1943 had shown that large numbers still had no domestic shelter, and that many thousands would be unable to reach a public shelter quickly. Though the obvious solution to the problem was the 'Morrison', production of these had stopped twelve months before; and in order to build up a reserve issue had been discontinued in various areas, including London. At the beginning of October it was decided that another 100,000 'Morrisons' should be manufactured and that the reserves held in Scotland, the North of England, the Midlands and North Wales should be moved to the vicinity of London and to the Reading and Tunbridge Wells Regions, from where they could, if necessary, be used to supply London.

Large-scale redistribution of 'Morrisons' and the procurement of new ones called for a substantial administrative effort. Nonetheless, most reserves were transferred during the autumn, and by the end of January 1944 some 12,000 had deen distributed to London householders. At the beginning of this year, however, preparations for the Allied invasion of Europe began to choke the railways with more important traffic, and it became impossible to transport new shelters from manufacturers in the north of England. This difficulty, combined with delays in the production of spanners and nuts, meant that no new shelters could be delivered before late February or early March, when it was expected that the V-weapon attacks would have begun. Arrangements were made for some to be shipped coastwise to London; but in mid-February the contract for the remaining 'Morrisons' (about 20,000) was cancelled.

V2 THREAT:

On 11th September the War Cabinet considered the need for a revival of the plan (known as the 'black move') to evacuate a proportion of the staffs of Government Departments from London. The numbers now involved in such an exodus of the war-expanded Departments would be high, and difficulties of communications, transport, accomodation and billeting again seemed overwhelming; it was, therefore, agreed that the more practical course would be to devise measures such as 'citadel' accommodation to enable essential work to continue in London. The production of the further 100,000 'Morrison' shelters and the work on the reinforcement of street shelters proposed by the Home Secretary were also authorised.

As far as shelter policy was concerned, orders had been placed in September 1943 for an additional 100,000 indoor table shelters and existing stocks were moved into the areas of probable attack. Difficulties of manufacture and transport had led to poor deliveries of 'Morrisons', and it seemed unlikely that more than half of the additional shelters ordered would be available by the time attacks were likely to begin. As the remainder would probably arrive too late to be of any use, contracts for the shelters were to be reduced by about 25,000. On the question of deep Tube shelters it had been agreed earlier that priority in the allocation of space would have to be given to the essential machinery of government. The Ministry of Works worked out a plan to shelter those government staffs not already provided for in the strengthened basements of their own steel-framed buildings. All shelter plans, the reader will recall, were given valuable impetus by the resurgence of 'conventional' attack on London and the south in the 'Little Blitz' of early 1944.

V1 flying bomb:*THE 'V.1' ATTACKS* 659

Flying glass was a special danger and people were warned to take cover on the sound of a bomb diving or the engine stopping, and later on the sounding of imminent danger warnings. The vast damage to houses inevitably caused great domestic upheavals. To begin with there was a definite decline in production in London, due to an increase in the rate of absenteeism, to loss of time in actual working hours through workers taking shelter and to lowered efficiency through loss of sleep and anxiety. The extension of the industrial alarm system and the increase in the labour force repairing damaged property, however, soon reduced these early signs of disturbance. Within a few weeks evacuees were returning to London, shelters were less full and most people were going about their normal tasks as usual.

For the civil defence services the new weapon demanded new tactics. In many ways these attacks were much easier to contend with than ordinary bombing. Firstly, most of the incidents were isolated, so that services could be directed in strength to the affected area without constant competing demands on the personnel at every turn. Secondly, the fall of the bombs could be spotted within a matter of seconds by high-placed observation posts either by night or by day, so that rescue and first aid squads could be on the spot very quickly. Thirdly, the penetrative power of this weapon was slight so that incidents rarely involved the complications of broken gas, electricity or water mains, and there was also little tendency for fires to break out. On the other hand the bombs could fall at any time in crowded thoroughfares; the proportion of casualties in the streets was much higher than ever before while the proportion of trapped casualties was lower. At night time, since there were no German eyes above, the use of artificial light was less restricted and searchlights could be used for rescue work.

APPENDIX V

Total numbers of flying-bomb and long-range rocket incidents reported

Table 1—By Counties

Counties	Flying Bombs	Long-Range Rockets
London (Region)[1] .	2,420	517
Kent	1,444	64
Sussex . . .	886	4
Essex	412	378
Surrey . . .	295	8
Suffolk . . .	93	13
Hertfordshire . .	82	34
Hampshire . . .	80	—
Buckinghamshire . .	27	2
Norfolk . . .	13	29
Berkshire . . .	12	1
Bedfordshire . .	10	3
Lancashire . . .	8	—
Yorkshire . . .	7	—
Cheshire . . .	6	—
Cambridgeshire . .	5	1
Northamptonshire .	4	—
Oxfordshire . .	4	—
Isle of Ely . . .	3	—
Derbyshire . . .	3	—
Huntingdonshire . .	2	—
Lincolnshire . .	2	—
Durham . . .	1	—
Nottinghamshire . .	1	—
Leicestershire . .	1	—
Rutland . . .	1	—
Shropshire . . .	1	—
Total . .	5,823[2]	1,054[2]

[1] London Region received 41 per cent. of flying-bombs, and 49 per cent. of long-range rockets.
[2] 271 of these flying-bombs and 4 of the long-range rockets fell in the sea.

APPENDIX IV

Major night attacks on United Kingdom cities and towns from 7th September, 1940 to 16th May, 1941

Target Area	*Number of Major Attacks*[1]	*Tonnages of H.E. Aimed*
London	71	18,291
Liverpool-Birkenhead . .	8	1,957
Birmingham . . .	8	1,852
Glasgow-Clydeside . .	5	1,329
Plymouth-Devonport . .	8	1,228
Bristol-Avonmouth . .	6	919
Coventry	2	818
Portsmouth . . .	3	687
Southampton . . .	4	647
Hull	3	593
Manchester . . .	3	578
Belfast	2	440
Sheffield	1	355
Newcastle-Tyneside . .	1	152
Nottingham . . .	1	137
Cardiff	1	115

[1] The enemy's definition of a 'major attack', i.e. one in which 100 tons or more of high-explosive bombs were successfully aimed at the target, has been adopted for this table.

Printed for the War Cabinet. *May* 1941.

MOST SECRET. Copy No. 58

W.P. (G) (41) 44.

May 5, 1941.

TO BE KEPT UNDER LOCK AND KEY.

It is requested that special care may be taken to ensure the secrecy of this document.

WAR CABINET.

AIR RAIDS ON LONDON, SEPTEMBER–NOVEMBER 1940.

Memorandum by the Home Secretary and Minister of Home Security.

Framed buildings.

Most valuable information has been gained on the effects of bombs on framed buildings. Such buildings are practically immune to anything but a direct hit. Blast damage from bombs outside is usually confined to windows and internal partitions. Even parachute mines falling immediately outside the building or exploding on the roof produce negligible damage to structure or floors.

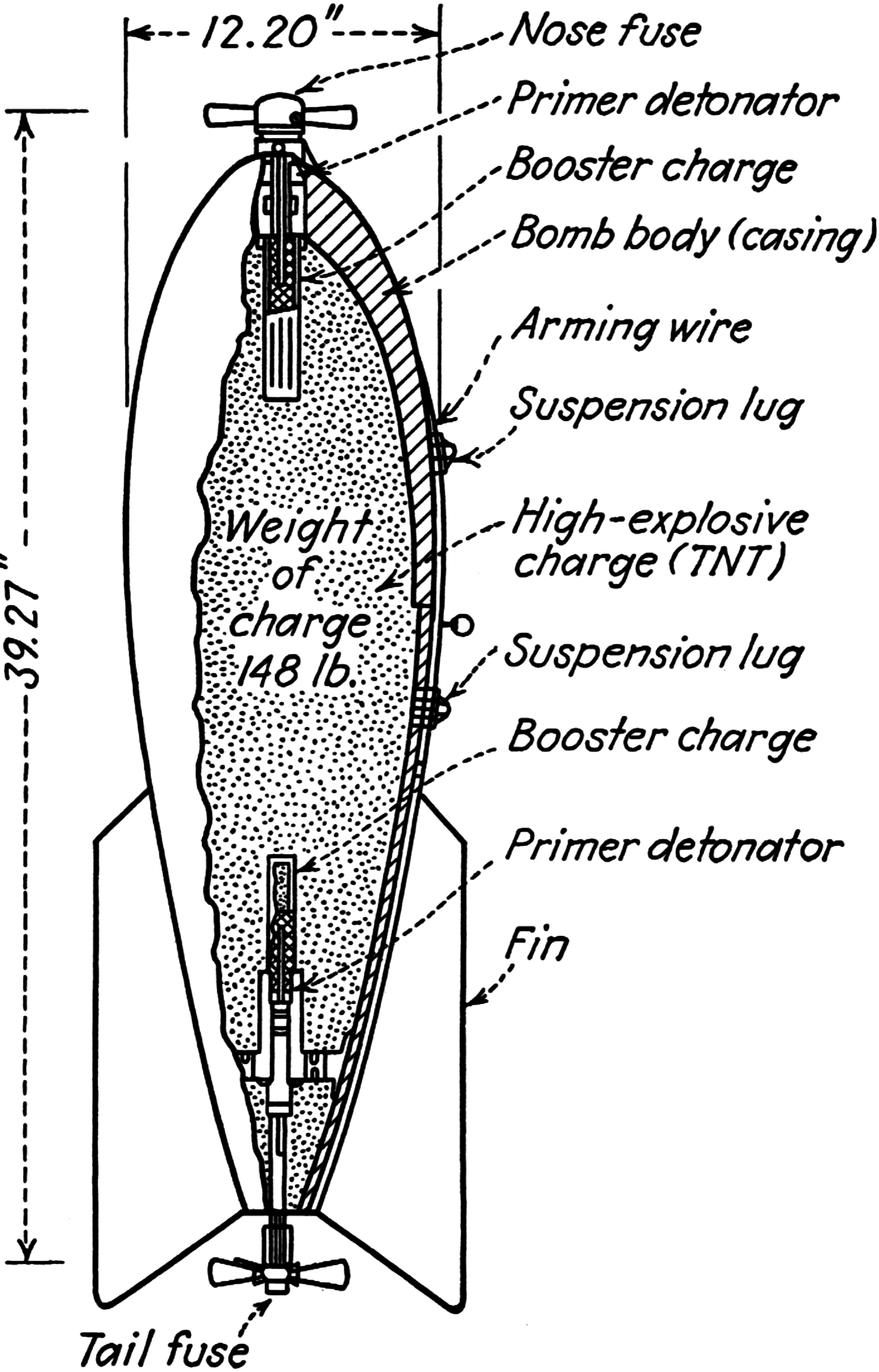
Relation of Casualties to Bombs Dropped.

From a knowledge of the number of bombs dropped and the casualties occurring in different boroughs, some idea can be gained of the effectiveness of bombs in producing casualties. The number of casualties per bomb varies widely from 1·59 in the least to 6·94 in the most populated boroughs, but it follows closely the apparent densities of population as shown in figure 1. The number of casualties per bomb is roughly a twelfth of the number of persons per acre, and the number of deaths per bomb about 1/60th of the number of persons per acre. From this it can be deduced that the mean distance at which injury from a bomb is likely to occur is 35 ft., and that at which the bomb is lethal is 15 ft.

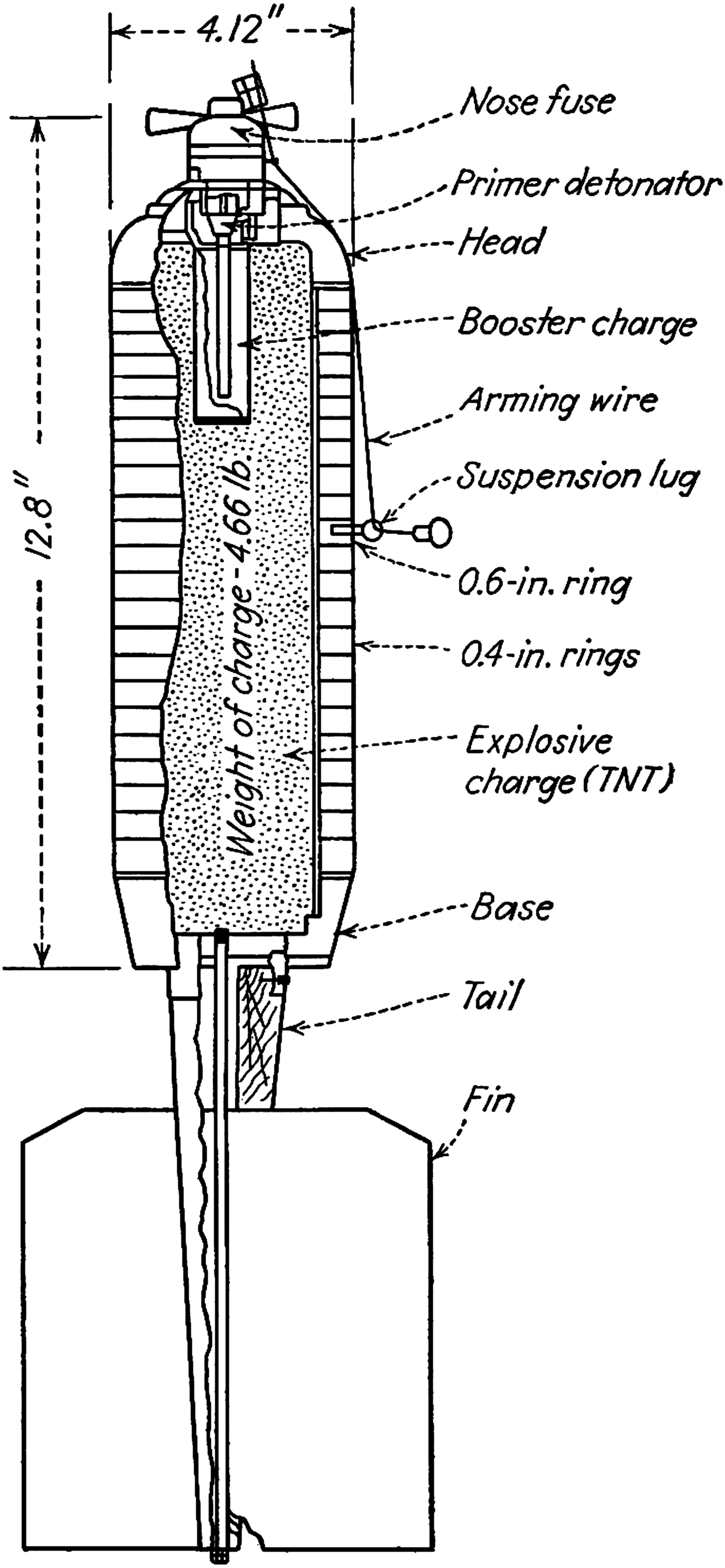
The casualties per bomb in Central London fell steadily from an average of 3·7 in September to 2·7 in October and 1·7 in November. This corresponds to the considerable fall in population in most of the boroughs concerned.

Conclusion.

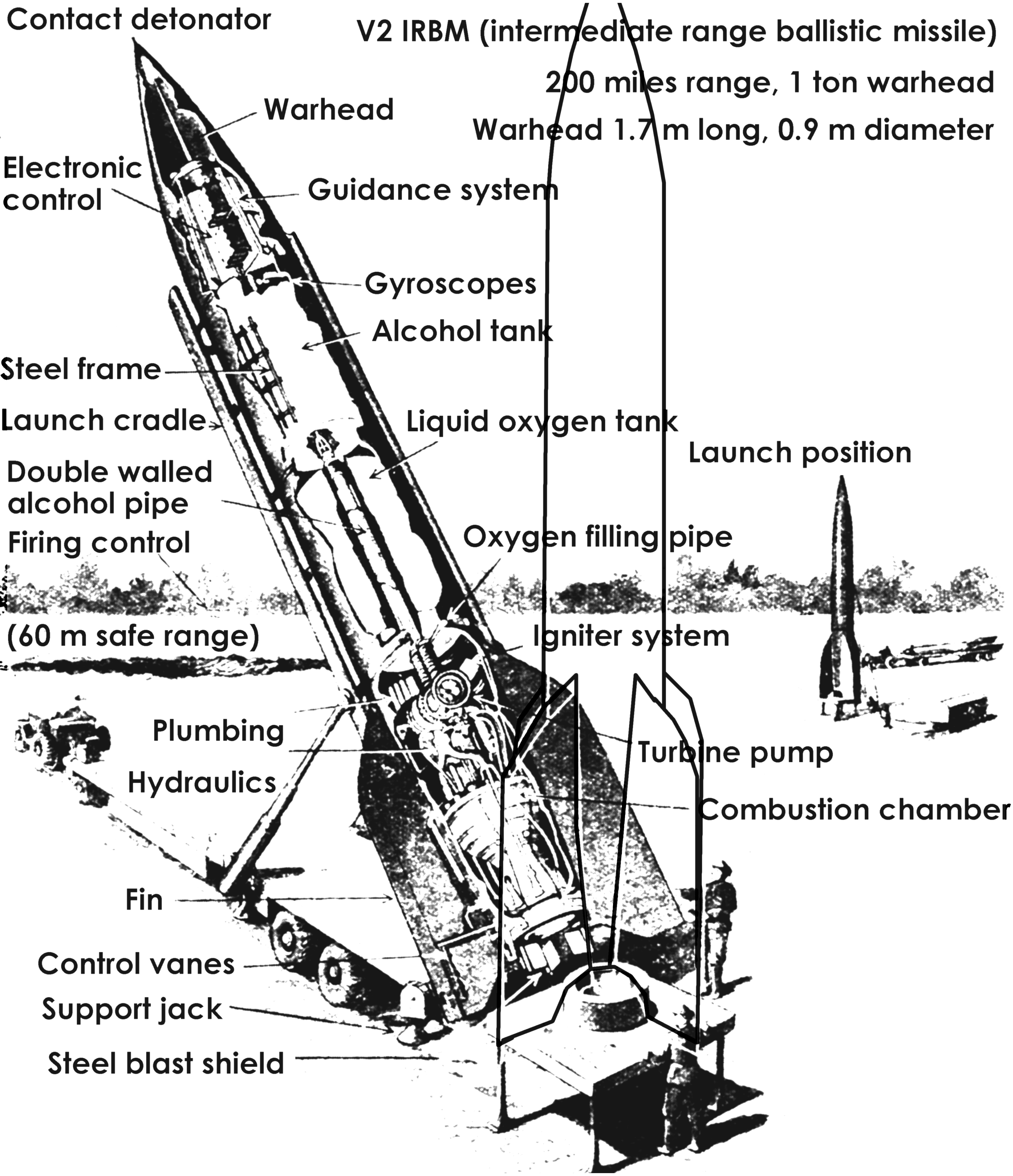
We may now say that we have a good general understanding, both qualitative and quantitative, of the effects of bombs on buildings and on cities. New types of bombs, particularly heavier bombs, may be used, but we can anticipate no startling change in the effects apart from increase in minor damage. With bombing of the present type the results of our work are to show that in urban areas, such as that of the County of London, *for one ton of bombs approximately* 10 *houses will be destroyed or will need pulling down.* 25 *more will be temporarily uninhabitable, and another* 80 *will be slightly damaged.* 80 *people will be made temporarily homeless and* 35 *will lose their homes permanently.* 25 *people, mostly among the latter category, will be wounded, the greater part of them slightly, and* 6 *will be killed or die from wounds.*



General purpose bomb (300 lb.)



Fragmentation bomb (30 lb.)



Contact detonator
V2 IRBM (intermediate range ballistic missile)
200 miles range, 1 ton warhead
Warhead 1.7 m long, 0.9 m diameter
Warhead
Electronic control
Guidance system
Gyroscopes
Alcohol tank
Steel frame
Launch cradle
Liquid oxygen tank
Launch position
Double walled alcohol pipe
Firing control
Oxygen filling pipe
(60 m safe range)
Igniter system
Plumbing
Turbine pump
Hydraulics
Combustion chamber
Fin
Control vanes
Support jack
Steel blast shield

V-2 ATTACK at Smithfield Market, London, where 110 people were killed and 123 seriously injured when pavements were crowded

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF STRATEGIC BOMBING ON GERMAN MORALE

VOLUME I

Morale Division

Dates Of Survey:

March - July, 1945

Date of Publication:

May 1947

A major factor in the final break-down of German civilian morale was strategic bombing. It was not the only factor adversely affecting morale, but it did much to produce a mood of defeatism in the civilian population. By the end of 1944, strategic bombing had depressed a substantial percentage of the bombed population into apathy.

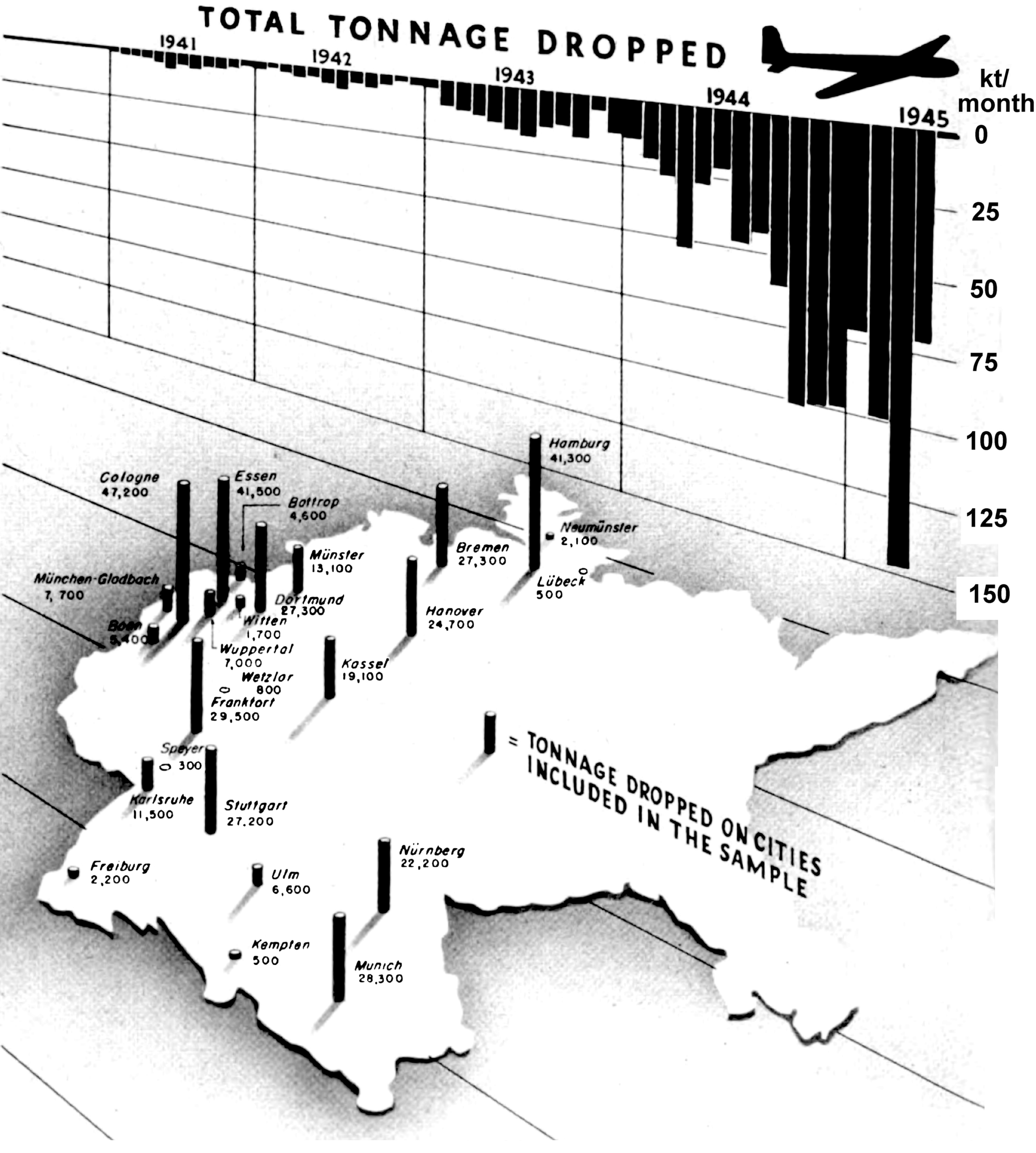
The reason that poor German civilian morale did not translate itself into action seriously endangering the German war effort until the latter months of 1944 and the early months of 1945 was largely due to the terroristic control of the population by the Nazis and, in part, to the cultural patterns of the German people.

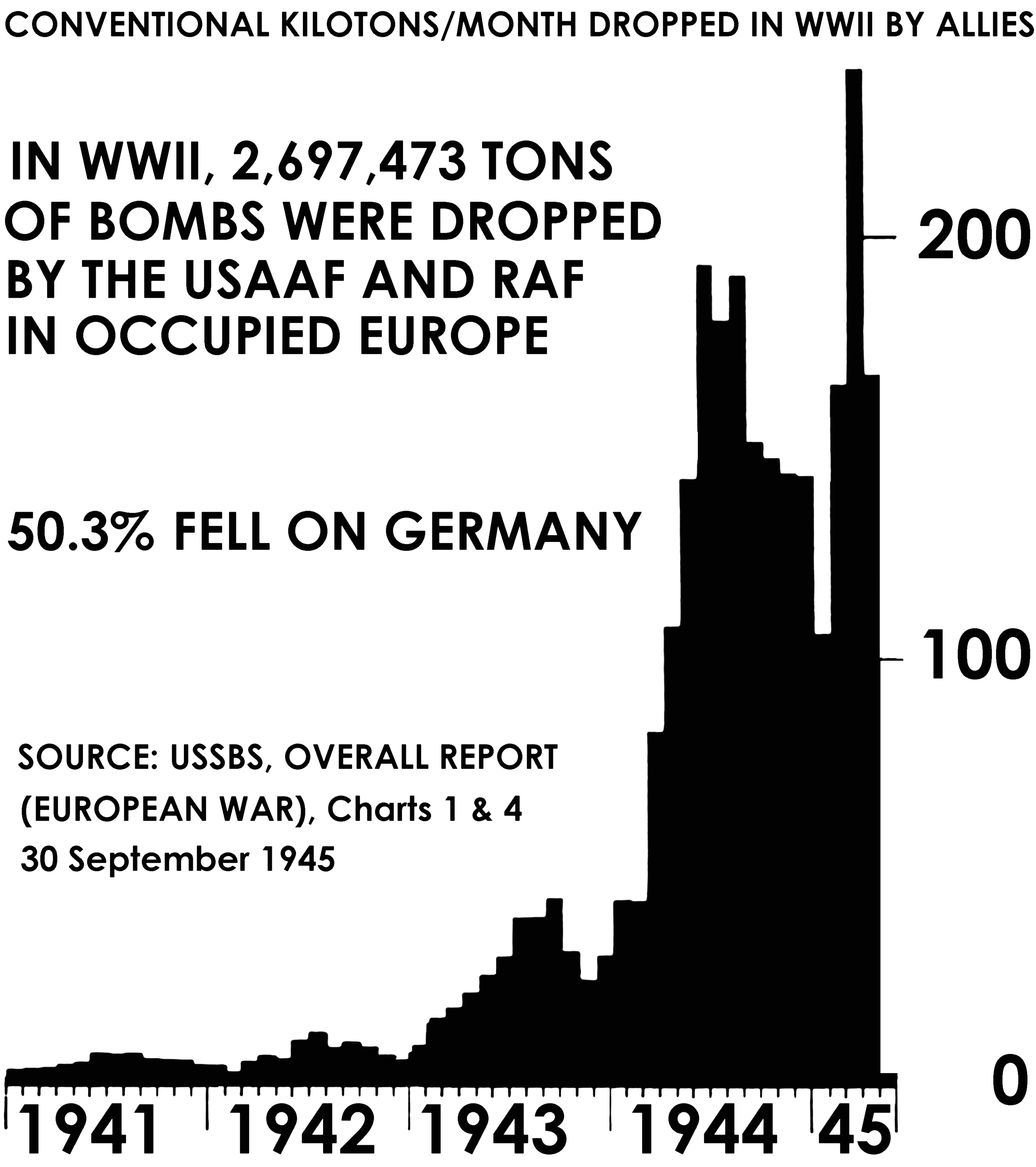
TABLE 1.—*Physical effects of bombing* [1]

Killed	305,000
Wounded	780,000
Homes destroyed	1,865,000
Persons evacuated	4,885,000
Persons deprived of utilities	20,000,000

[1] All estimates include Russian-occupied Germany. The casualty estimates are based on interviews with civilians and do not include police officials, members of armed forces, displaced persons, people in concentration camps.

BOMBING ATTACKS ON GERMANY




CONVENTIONAL KILOTONS/MONTH DROPPED IN WWII BY ALLIES
IN WWII, 2,697,473 TONS OF BOMBS WERE DROPPED BY THE USAAF AND RAF IN OCCUPIED EUROPE
50.3% FELL ON GERMANY
SOURCE: USSBS, OVERALL REPORT (EUROPEAN WAR), Charts 1 & 4
30 September 1945
200
100
0
1941
1942
1943
1944
45

THE UNITED STATES

STRATEGIC BOMBING SURVEY

FINAL REPORT

Covering Air-Raid Protection and Allied Subjects in

JAPAN

Civilian Defense Division

Dates of Survey:

1 October 1945—1 December 1945

Date of Publication:

February 1947

EXHIBIT A–3.

Total tons of bombs dropped on Japan by U. S. Army Air Forces—By months

AIR FORCE

Date	Total	Incendiary
1944		
June	----------	----------
July	28	----------
Aug	183	55
Sept	5	----------
Oct	159	68
Nov	766	298
Dec	992	495
1945		
Jan	1,261	435
Feb	1,884	929
Mar	12,788	10,023
Apr	16,150	3,967
May	25,065	18,699
June	27,497	18,172
July	43,422	31,670
Aug. (15 days)	23,687	13,655
Totals	153,887	98,466

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF AIR ATTACK ON JAPANESE URBAN ECONOMY

SUMMARY REPORT

Urban Areas Division

March 1947

TABLE 5.—*Damage to urban areas*

Total built-up area	square miles	[1]411
Target area	do	[1]192
Area destroyed	do	[1,2]178
Total population		21,928,000
Bombs dropped (74 percent incendiary)	tons	121,458
Buildings destroyed		2,094,374
Persons killed		252,769
Persons injured		298,650
Persons rendered homeless		8,324,000
Planned evacuations		2,100,000

[1] Operational summary, Twentieth Airforce. Refers only to 66 cities which were targets of planned urban area missions.

[2] 43 percent total built-up area for 66 cities.

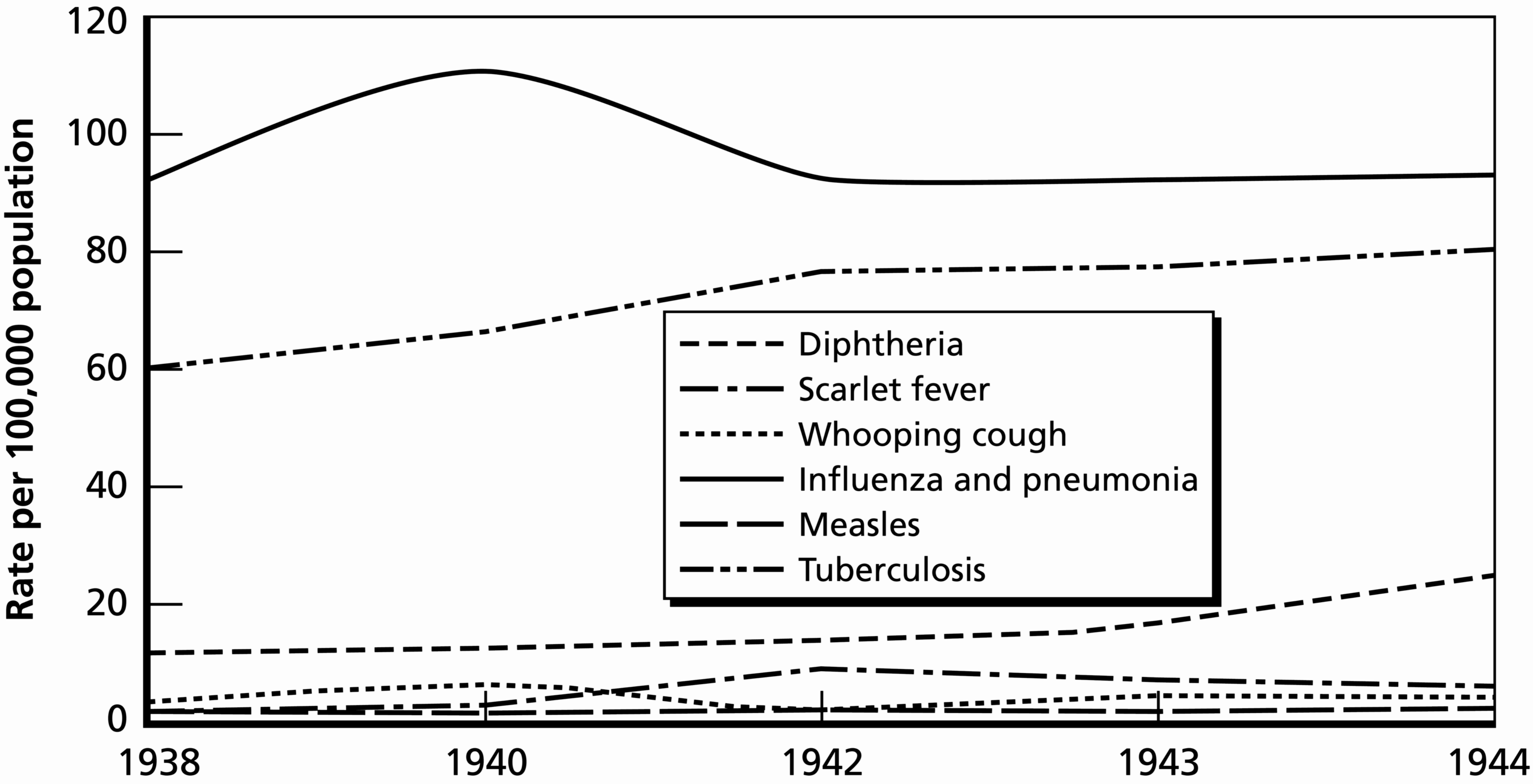
The cities of Japan, like those in Germany, presented a spectacle of enormous destruction. Although the over-all total damage was somewhat greater in Germany than in Japan the extent of destruction was comparable. Only 160,800 tons of bombs were dropped on Japan's home islands as compared with 1,360,000 tons dropped within Germany's own borders. One hundred and four thousand tons of bombs were dropped on 66 Japanese cities as compared with 542,554 tons of bombs that were dropped on 61 German cities.

As in Germany, the air attacks against Japanese cities were not the cause of the enemy's defeat. The defeat of Japan was assured before the urban attacks were launched. But this defeat, before it could be translated into the terms of surrender, might have required a costly invasion of the home islands had not the effect of the air attacks, both precision and urban, on Japan's industries and people exerted sufficient pressure to bring about unconditional surrender on 15 August. The city raids contributed substantially to that pressure by their impact on the social and economic structure of Japan.

The insufficiency of Japan's war economy was the underlying cause of her defeat. Before the air attacks against the cities began, war production had been steadily declining because of the ever-increasing shortages of raw materials, skilled labor, and an ill conceived dispersal program which was initiated too late. The Survey estimated that, even without air attacks, over-all production, by August 1945, would not have exceeded 60 percent and might have been as low as 50 percent of the 1944 peak.

Mortality Rate for Several Diseases, Germany, 1938–1944

Seth G. Jones, et al., "Securing Health", RAND Corp report MG321, 2006, Fig. 2.3



SOURCE: United States Strategic Bombing Survey, *The Effect of Bombing on Health and Medical Care in Germany*, pp. 30–105.

STANFORD RESEARCH INSTITUTE

STANFORD, CALIFORNIA

June, 1953

Final Report

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Evaluation of Source Materials

By

Robert O. Shreve

SRI Project 669

Prepared for
Federal Civil Defense Administration
Washington, D. C.

Approved:

William J. Platt

William J. Platt, Chairman
Industrial Planning Research

Weldon B. Gibson

Weldon B. Gibson, Director
Economics Research Division

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Table 1

Report Outline - USSBS Project

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Division I - PHYSICAL DAMAGE TO STRUCTURES, FACILITIES, AND PERSONS

Volume 1 Summary of Civil Defense Experience
Volume 2 Analytical Studies (Restricted)
Volume 3 Causes of Fire from Atomic Attack (Secret) --VITAL!!

The documents which should be given wide distribution for civil defense use are listed below, with a brief description:

a. USSBS Reports

Effects of the Atomic Bomb on Hiroshima, Japan (3 volumes).

Effects of the Atomic Bomb on Nagasaki, Japan (3 volumes).

These reports constitute two case studies of atomic bombing. Civil defense planners should be aware of the facts these documents record in great detail. Their distribution to all civil defense planners and analysts is highly desirable.

-9-

Effects on Labor in Clydebank of Clydeside Raids of March 1941, (REN 234) USSBS Target Int.(REN 236) Ministry of Home Security

A study of the effects on labor of bombing in a town of 50,000 people in which 76% of houses were rendered uninhabitable, 73% of the population homeless. An equivalent of 65 city days was utilized in the reconstruction.

-22-

Ministry of Home Security
Effects of German Air Force Raids on Coventry (REN 441)

The city, the attack, casualties, repairs and reconstruction (cost), absenteeism, population movements, and housing occupancy. Six pages and charts and graphs. Twenty percent of houses rendered uninhabitable or destroyed, a total reconstruction cost of £ 3,492,000. Average time lost by worker after November raid was eleven days; average after April raid was 7 days. Nine percent of the workers evacuated to points within reach of the city.

STANFORD RESEARCH INSTITUTE

STANFORD, CALIFORNIA

June, 1953

Final Report

IMPACT OF AIR ATTACK IN WORLD WAR II: SELECTED DATA FOR CIVIL DEFENSE PLANNING

Division II: Effects on the General Economy

Volume 1: Economic Effects - Germany

Part One

SRI Project 669

Prepared for

Federal Civil Defense Administration
Washington, D. C.

Approved:

William J. Platt

William J. Platt, Chairman
Industrial Planning Research

Weldon B. Gibson

Weldon B. Gibson, Director
Economics Research Division

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.25

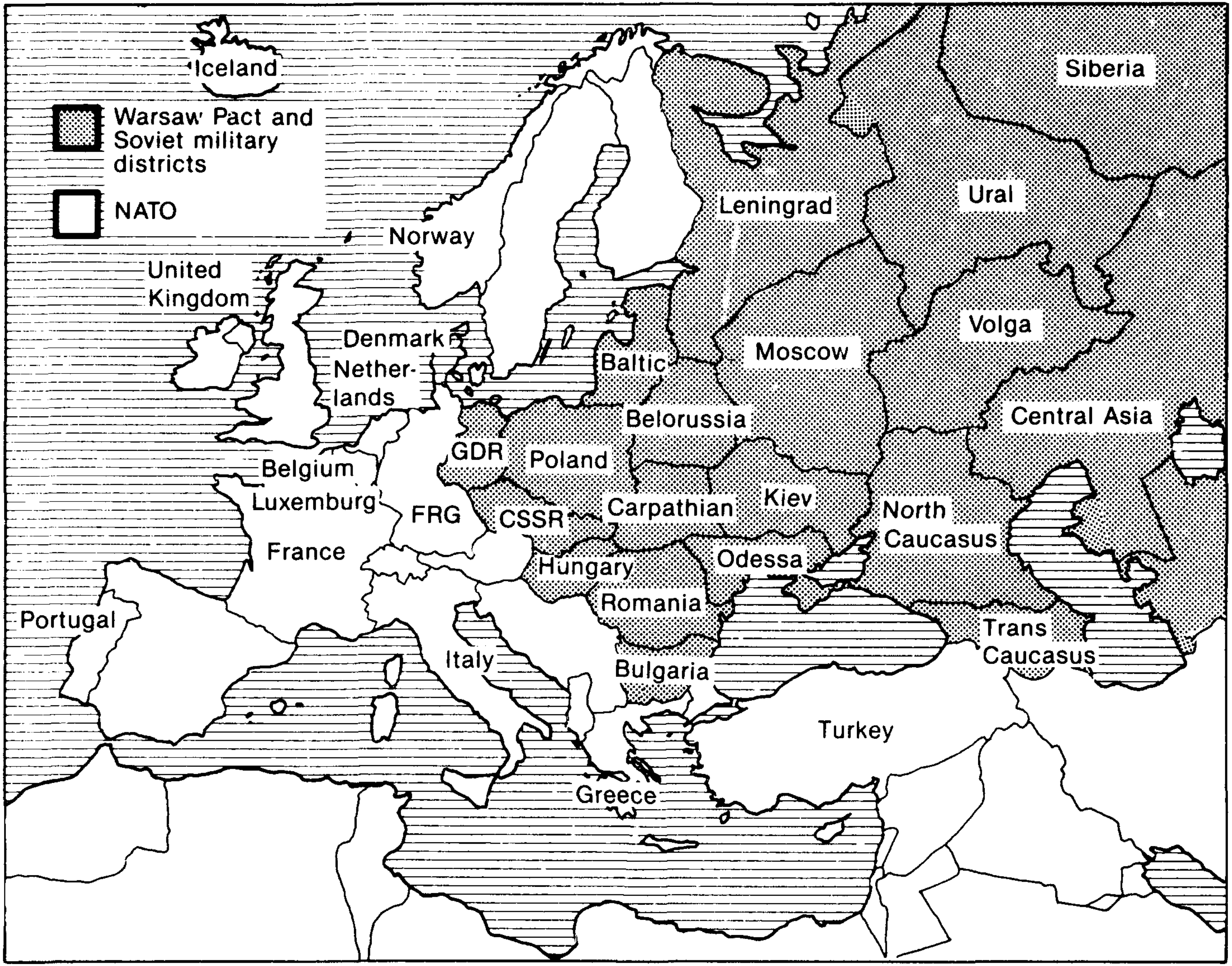
Over-all Report (European War). 109 pp. STRATEGIC BOMBING SURVEY

This volume recounts the history of the build-up of air power, showing the great increase in 1945. The results of attack on selected major industries in Germany are also considered. The report concludes that attrition caused the downfall of economy, especially as it affected transportation and oil.

LOGISTICS TARGETTED

Summary Report (European War). 18 pp. STRATEGIC BOMBING SURVEY

Germany planned a quick war; the Allies planned a long war and started a systematic attack on German industry. The British concentrated on area raids; the United States, on precision bombing. Ball bearings, aircraft, oil, steel, and transportation were attacked in order. The attack on transportation was the decisive blow that completely disorganized the German economy. Civilians withstood bombing fairly well, and the recuperation of German industry was surprising.


Iceland
Warsaw Pact and Soviet military districts
NATO
Norway
United Kingdom
Denmark
Netherlands
Belgium
Luxemburg
France
Portugal
FRG
GDR
Poland
CSSR
Hungary
Romania
Bulgaria
Italy
Greece
Turkey
Baltic
Belorussia
Carpathian
Kiev
Odessa
Leningrad
Moscow
Ural
Volga
Siberia
Central Asia
North Caucasus
Trans Caucasus

Se~~c~~ret

DIRECTORATE OF
INTELLIGENCE

Intelligence Report

Civil Defense in the Soviet Union

Se~~c~~ret

Copy No. 213

May 1969

CENTRAL INTELLIGENCE AGENCY
Directorate of Intelligence
15 May 1969

INTELLIGENCE REPORT

Civil Defense in the Soviet Union

Summary

Soviet political and military leaders at the 23rd Party Congress in 1966 reaffirmed their belief in the importance of a vigorous civil defense program. Since then, there has been a general rise in the level of civil defense activity in the Soviet Union.

In part the renewed emphasis reflects a conviction that a strong civil defense posture would help the USSR survive a nuclear war, but beyond that it also serves as a means for instilling a greater degree of patriotism and discipline in the populace. The regime's growing concern over the danger of liberal influences has stimulated increased reliance on paramilitary-type programs for large-scale indoctrination.

No other country has informed its people as thoroughly on the effects of nuclear, biological, and chemical weapons. Soviet citizens now are engaged in the sixth compulsory civil defense instruction program since 1955, and civil defense has become a required subject in elementary and secondary schools throughout the country. Workers are also participating in compulsory training. An extensive network of staff schools trains leaders for civil defense duties. The effect of all this indoctrination cannot be measured, but its pervasiveness has probably conditioned most of the populate to follow orders and take self-help measures in an emergency.

Note: This report was produced solely by CIA. It was prepared by the Office of Strategic Research and coordinated with the Office of Current Intelligence and Economic Research.

AD 626074

O. Tolstikov, Colonel General of the Air Force, "United States Civil Defense," in *The Nuclear Age and War (Iadernyi vek i voina)*, edited by A. A. Grechko, Marshal of the Soviet Union, Moscow, Izvestiia Publishing House, 1964, pp. 123-132; translated from the Russian by Nadia Derkach, the RAND Corporation, December, 1965

LT-65-106

It is clear that civil defense will be that much stronger if the moral and political unity of the citizens is strong and the citizens are rallied around the true ideas which can inspire people to heroic deeds and sacrifices. Capitalist states lack this fundamental principle in the organization of civil defense since their imperialist aims are in irreconcilable contradiction to the interests of the toiling masses.

Of course, the people in the capitalist countries will also strive to protect their families and their kin from nuclear death and their property from destruction. That is the law of life. However, the imperialists will not be able to create a strong, monolithic civil defense.

The difficulties of United States civil defense in staffing its forces are further aggravated by the fact that the population has been frightened by the horrors of nuclear war. The fear which has been instilled into Americans turns like a boomerang against those who fanned it.

The October 1962 days of the Caribbean crisis clearly illustrated the complete inability of U. S. civil defense to carry out its assignment.

Cristy, G. A. and C. H. Kearny, Expedient Shelter Handbook, ORNL-4941, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August 1974.

EXPEDIENT SHELTER HANDBOOK

The decade of the seventies has already introduced many tremendous changes in the strategic situation. The present clear and admitted superiority of the Soviet Union both in weapons and in weight of their missile force is a sharp contrast to the massive superiority of the U.S. in nuclear weapons in the fifties and early sixties.

However, the Soviet Union has done more than achieve a state of superiority in nuclear weapons (a condition which has been accepted by the U.S. in the Interim Agreement on Offensive Weapons in conjunction with the Strategic Arms Limitation Treaty (SALT); the Soviet Union has also developed a strategic evacuation plan which can have a vital impact upon the strategic balance, especially when this balance depended for so long upon an assured destruction policy. The Soviet evacuation plan is a well organized and sophisticated plan based upon a clear statement of Soviet nuclear policy. The Soviet Union does not subscribe to the doctrine that nuclear war means the end of mankind. On the contrary, it instructs and prepares its citizens on how to survive such a war. Marshal V. I. Chuykov puts it this way:

> "Without slighting the serious consequences of a possible war, we should in all responsibility state that there is no poison for which there cannot be an antidote nor can there be a weapon against which there is no defense. Although the weapons we have examined are called mass weapons, with the knowledge and skillful use of modern defense measures they will not affect masses, but only those who neglect the study, mastery, and use of these measures."

> "Protection of the population is implemented by dispersing and evacuating the people to outlying areas and providing them protective shelters and personal means of protection."

—— Marshal V. I. Chuykov, "Civil Defense as Common Concern," *Nauka i Zhizn*, (Science and Life), No. 1, 1969.

REVIEW: CIVIL DEFENSE TEXT (1986)

Moscow VOYENNYYE ZNANIYA in Russian No 3, 1987 p 41

[Review by N. Korchagina of textbook "Grazhdanskaya Oborona" [Civil Defense] by V.G. Atamanyuk, L.G. Shirshev and N.I. Akimov, edited by D.I. Mikhaylik, Moscow, Vysshaya shkola, 1986, 207 pages]

[Text] This textbook on civil defense for higher technical educational institutions was published late last year. The authors developed this book under a new student training program.

Many of the graduates will become commanders of formations or workers of civil defense services, depending on the specialty obtained. The primary task of the VUZ is to train them in such a manner that they can confidently and competently carry out civil defense measures at those installations where they will later work.

The textbook thoroughly examines questions of the effects of weapons of mass destruction on industrial installations and problems of increasing the stability of operations during wartime. It tells in detail, using specific examples, of the methods for assessing the radiation and chemical situation.

Considerable space is given to protecting the population from weapons of mass destruction and performing rescue and emergency repair work both in the centers of destruction and when mopping up the after-effects of natural disasters, major accidents, and catastrophes.

Materials are set forth well concerning the forms and methods of instructing the population on civil defense, the fundamentals of organizing political educational work, and the moral and psychological training of personnel of formations.

Each of the textbook's sections is illustrated with drawings, figures, diagrams, and graphs.

The training aid has five attachments which cite examples of calculations of parameters of the casualty-producing elements of a nuclear explosion and the loads created by the blast wave, as well as information on the radiation-resistance of materials and components of electronic and electrooptical equipment. In addition, two tables give the technical specifications of modern missiles and strategic bombers of the air forces of the United States, Great Britain, and France, making it possible to present clearly all the basic parameters of these weapons.

Gorbachev's Economic Program: Problems Emerge

DDB-1900-187-88
June 1988

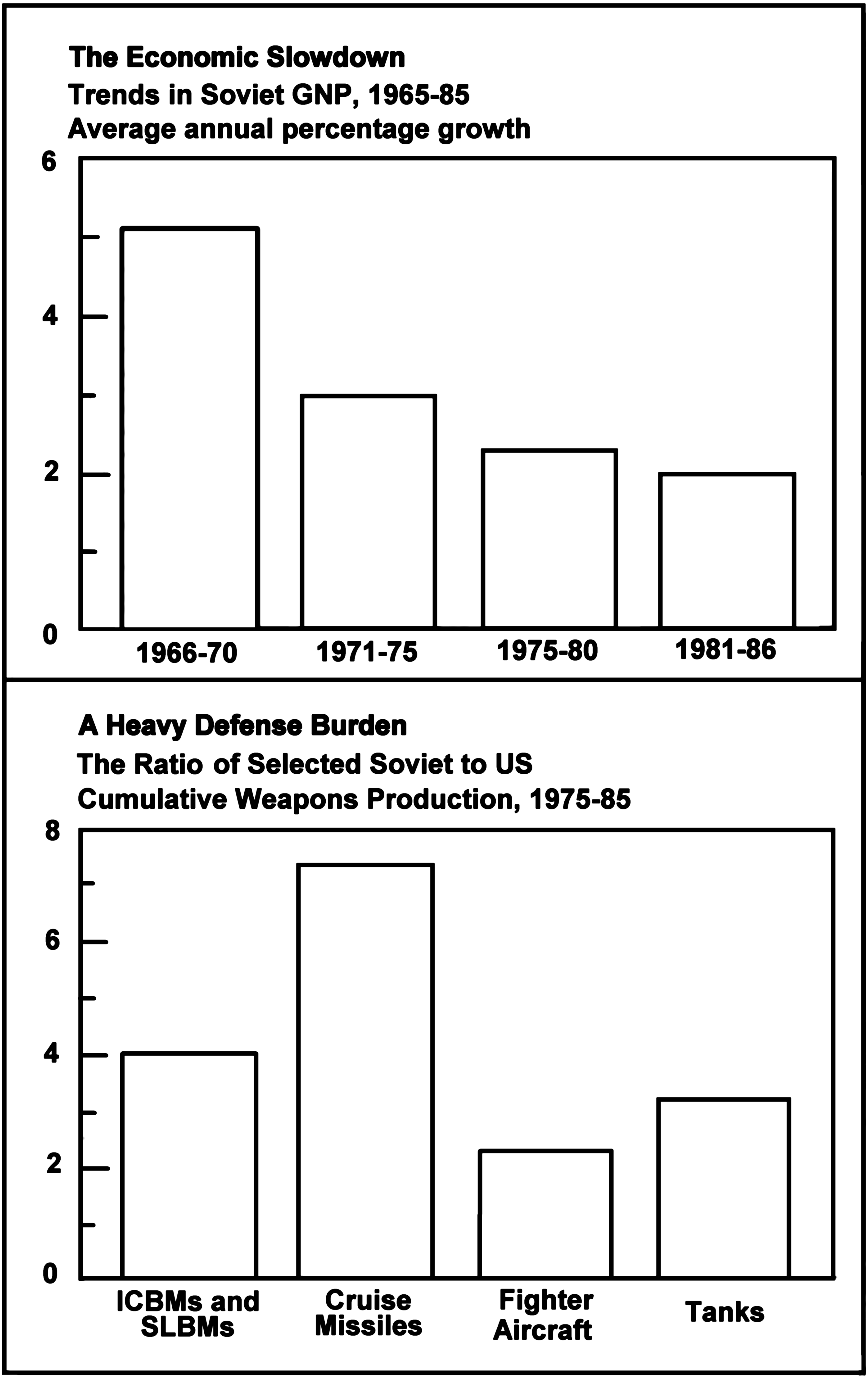
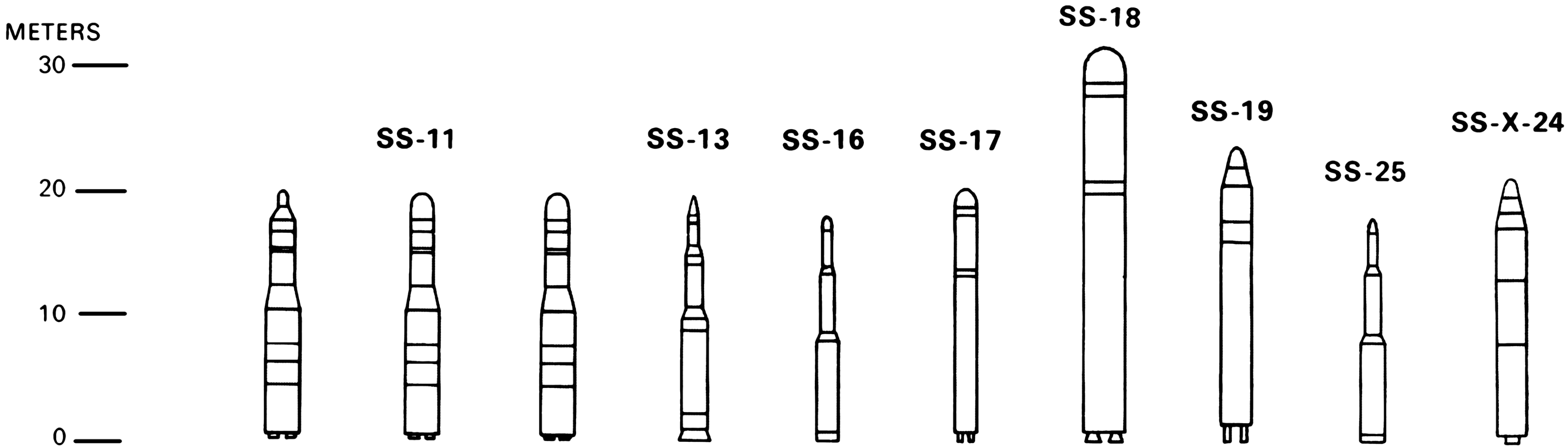


Figure 1. Gorbachev's Domestic Imperative

SOVIET MILITARY POWER

1986

USSR ICBMs



	SS-11 MOD 1	SS-11 MOD 2	SS-11 MOD 3	SS-13 MOD 2	SS-16	SS-17 MOD 3	SS-18 MOD 4	SS-19 MOD 3	SS-25	SS-X-24
NUMBER DEPLOYED	28	420		60	Undetermined	150	308	360	70 *	In Development/ Testing
WARHEADS	1	1	3 MRVs	1	1	4 MIRVs	10 * MIRVs	6 MIRVs	1	Up to 10 MIRVs
MAX RANGE (KM)	11,000	13,000	10,600	9,400	9,000	10,000	11,000	10,000	10,500	10,000
LAUNCH MODE	Hot	Hot	Hot	Hot	Cold	Cold	Cold	Hot	Cold	Cold

US ICBMs

	TITAN II	MINUTEMAN II	MINUTEMAN III	PEACEKEEPER
NUMBER DEPLOYED	17 *	450	550	In Development
WARHEADS	1	1	3	Up to 10
MAX RANGE (KM)	12,000	12,500	11,000 *	11,000 *
LAUNCH MODE	Hot	Hot	Hot	Cold

* As of early 1986

FM 100-30

NUCLEAR OPERATIONS

Headquarters, Department of the Army

Field Manual
100-30

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 29 October 1996

NUCLEAR OPERATIONS

CONTENTS

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PREFACE

In the past, Soviet-styled armored echeloned formations were the primary threat to the United States (US). In response to this threat the US designed and stockpiled tactical nuclear weapons. Today's threats consist of regional instabilities and the proliferation of weapons of mass destruction (WMD). However, the US, as well as many other nations, actively pursues a policy of nonproliferation. Despite this, the number of nations who have, or are developing, nuclear weapons continues to grow. Therefore, the US may some day find itself confronted by an opponent who possesses nuclear weapons. Because of the continuing reduction in the size of US military forces, the US could also find itself opposed by an overwhelming conventional threat. Either scenario could lead to the use of nuclear weapons. Therefore, the US must concern itself with countering the proliferation of weapons of mass destruction.

Despite the continuing drawdown of US military forces, the current national military strategy includes fighting and winning two near-simultaneous regional wars with conventional forces. Any US threat of employing nuclear weapons is to deter a potential adversary's use of such weapons. If deterrence fails. the goal is to end hostilities on terms acceptable, at the lowest level of conflict, to the US and its allies. However, the US unilaterally reserves the right to use nuclear weapons if necessary. Use would be restricted, of course, with tight limits on the area and time of use. This would allow the belligerent to recognize the "signal" of limited response and to react accordingly.

The Army describes battlefield nuclear warfare (BNW) in terms of being able to conduct continuous combat operations in a nuclear environment. The presence of any nuclear-capable system, before, during, or after nuclear-weapons employment by either friendly or enemy forces, creates a nuclear environment. The implications of their very presence creates the nuclear environment.

Before 1991, the US Army had custody of tactical nuclear weapons which were to be employed, on Presidential release, by organic Army field artillery units. In September 1991, the Presidential Nuclear Initiative (PNI) removed the organic nuclear responsibility from the US Army. Today the Army neither has custody of nuclear weapons nor do corps and divisions employ them. The US Air Force or the US Navy are now responsible for delivery of nuclear weapons in support of Army operations. The Army retains its role in nominating nuclear targets and is also responsible for nuclear force protection.

This manual establishes Army doctrine for operations in a nuclear environment and details the doctrine for integrating nuclear considerations into all other aspects of the battlefield. It also describes the Army's role in nominating targets at corps and above levels and protecting the force from the effects of nuclear weapons detonation.

Nuclear operations may occur at strategic, operational, and tactical levels of war. Nuclear employment in a theater of operations has theater strategic, operational, and tactical results; execution has national strategic implications. The corps' role is to function at either the tactical or operational levels of war. At the tactical level, the corps accomplishes missions as Field Manual (FM) 100-15 describes. At the operational level, when directed and augmented, the corps functions as either the Army force (ARFOR), the joint force land component command (JFLCC), or a joint task force (JTF). By viewing the corps in its many possible roles, the reader can also discern nuclear procedures for echelons above corps (EAC) and joint missions.

This manual can help educate and train commanders and staffs at corps and operational levels in nuclear operations and educate and train divisions in nuclear force protection. It is used with Joint Publications (JP) 3-12.1, 3 -12.2 (SRD), or 3-12.3, and serves as the bridge between joint and

DETERRENCE

Although the US military force's overriding mission is to deter war, especially nuclear war, the intent behind the 1991 Presidential Nuclear Initiative (PNI) was to enhance national security through arms reduction while preserving the capability to regenerate selected forces if required. Recent arms control agreements and unilateral initiatives provide for real reductions in the arsenals of nuclear powers. However, even with the most optimistic outlook, the sheer number of remaining weapons is formidable. An increasing number of potentially hostile states are developing or have the capability to develop weapons of mass destruction. Therefore, the US must maintain a modem, reliable, and fully capable strategic deterrent as its number one defense priority.

Deterrence is the product of a nation's military capabilities and that nation's willingness to use those capabilities. The US' policy is to terminate conflict at the lowest possible level of violence consistent with national and allied interests. The ability to conduct operational- and tactical-level nuclear activities enhances US deterrent policy.

The potential employment of nuclear weapons at theater level, when combined with the means and resolve to use them, makes the prospects of conflict more dangerous and the outcome more difficult to predict. The US' position is that it can achieve deterrence if any potential enemy believes the outcome of nuclear war to be so uncertain, and the conflict so debilitating, that he will have no incentive to initiate a nuclear attack. The resulting uncertainty reduces a potential aggressor's willingness to risk escalation by initiating conflict.

At the same time, a credible defensive capability, which would include the threat of employing nuclear weapons, could bolster the resolve of allies to resist an adversary's attempts at political coercion. For example, the US' capability of responding to biological and chemical attacks with nuclear weapons would likely reduce or eliminate such attacks.

Nuclear weapons contribute to but do not by themselves ensure deterrence. To have a credible nuclear deterrent requires a nation to have the means, the ability, and the will to employ nuclear weapons. The nation must also have—

- A reliable warning system.
- A modern nuclear force.
- The capability and flexibility to support a spectrum of response options.
- A deployable defensive system for theater protection.

The threat of nuclear escalation is a major concern in any military operation involving the armies of nuclear powers. Controlling escalation is essential to limiting a rational threat's incentive for nuclear response. Escalation control involves a careful selection of options to convey to the enemy that, although the US is capable of escalating operations to a higher level, it has deliberately withheld strikes.

The US views restraint in the use of nuclear weapons as an important way to control the escalation of warfare. Restraint provides leverage for a negotiated termination of military operations. However, the US cannot assume a potential enemy will view restraint in the same way, or that he will not employ weapons of mass destruction. Therefore, the US must be capable of deploying those forces necessary to defeat aggression, provide coercion, and bring the war to a speedy termination on terms favorable to the US and its allies. Commanders and staffs at all levels must continue to be familiar with nuclear-weapons effects, the actions required to minimize such effects, and the risks associated with using nuclear weapons.

THE THREAT

The Cold War era's definitive threats to American security were nuclear surprise attack and the possible invasion of Western Europe. The new threat is worldwide regional instability (including the possible regional use of nuclear weapons) coupled with the proliferation of weapons of mass destruction.

Developing countries as well as regional powers are gaining the ability to manufacture nuclear arsenals. The current threat from developing nations primarily consists of short- and intermediate-range ballistic and cruise missiles and aircraft capable of carrying nuclear weapons and other weapons of mass destruction. Other threats, such as terrorists groups, may also possess nuclear weapons.

A nation that has the capability of using ballistic or cruise missiles and high-speed aircraft to deliver weapons of mass destruction at extended ranges

significantly increases those weapons' effectiveness as instruments of terror. Such capability also enhances the possibility of conflict escalation beyond a hostile region's boundaries.

The use of, or the threat of using, weapons of mass destruction within a campaign or major operation can cause large-scale shifts in objectives, phases, and courses of action (COA). Nuclear weapons make it possible to drastically change the effective ratio of regional forces and equipment and to create conditions favorable to a threat's operations. Consequently, if a potential adversary is not successful conventionally, he might consider using weapons of mass destruction.

The most accepted enemy employment methodology to destroy critical targets is surprise. A potential enemy might try to destroy massed units and all other critical targets using various nuclear-weapons burst options (space bursts, air bursts, surface bursts, below-surface bursts). Such attacks might be single attacks or part of a group of massed nuclear strikes. Therefore, retaliation or escalation would result in the likelihood of nuclear use against friendly forces. Or, retaliation or escalation could be used in response to an enemy's first use of weapons of mass destruction.

One element of the commander's critical information requirements (CCIR) is determining if the theater threat is capable of using weapons of mass destruction. The answer dictates future command actions.

PROLIFERATION, NONPROLIFERATION, AND COUNTERPROLIFERATION

Proliferation is the process by which one nation after another comes into the possession of or attains the right to determine the employment of nuclear weapons, each potentially able to launch a nuclear attack upon another nation. Nonproliferation efforts focus on preventing the spread of missiles and weapons of mass destruction through arms and export controls beyond the scope of corps and EAC interest. Counterproliferation strategy focuses on military measures centering both on how to deter or discourage as well as how to defend and attack against the possible use of such weapons.

The Department of Defense's (DOD) counterproliferation initiative recognizes the goal of preventing proliferation of weapons of mass destruction and their associated delivery systems. It also recognizes that the US must continue to expand its efforts to protect forces, interests, and allies. The initiative has two fundamental goals:

- To strengthen DOD's contribution to governmentwide efforts to prevent, or diplomatically reverse, the acquisition of weapons of mass destruction.
- To protect US interests and forces (as those of its allies) from WMD effects by assuring that US forces have the equipment, doctrine, and intelligence needed to confront, if necessary, any future opponent who possesses weapons of mass destruction.

The Department of Defense marshals its unique technical, military, and intelligence expertise—

- To improve arms control compliance.
- To control exports.
- To inspect and monitor the movement of nuclear materials.
- To interdict shipments for inspection during crises.
- To strengthen the norms and incentives against WMD acquisition.

The Department of Defense's acquisition strategy in the areas of command, control, communications, and intelligence (C^3I), counterforce operations, active defense, and passive defense address the following critical counterproliferation challenges:

- Detecting and destroying WMD capabilities from production through storage to deployment.
- Conducting military operations in a WMD environment.
- Dealing with consequences of WMD use, including medical treatment, clean-up, and recovery.
- Coping with the diffusion of new technologies.

NOTE: This manual concerns the nuclear part of weapons of mass destruction.

Although nuclear weapons are an element of deterrence, potential regional adversaries might or might not understand the deterrence value of the

US' nuclear weapons. If the goals of promoting peace, deterring war, and resolving conflicts fail, deterrence fails. Therefore, fighting and terminating hostilities become paramount. United States doctrine assumes that if the potential foe is capable of using weapons of mass destruction, then US forces must act accordingly.

NUCLEAR FORCES

Nuclear-capable forces (Navy and Air Force) are instruments of national power in regional conflicts. They contribute to theater deterrence or provide a war-fighting option to the NCA.

Because the Army no longer has an organic nuclear capability, the Navy or Air Force will provide nuclear support. The Army can now only nominate nuclear targets, usually at no lower than the corps level. The division normally is limited to NBC protection activities.

The capability of the US to deploy nuclear forces into a theater significantly complicates the enemy's planning process. The alert status of nuclear forces is a function of the world situation at any given time and, thus, enhances their responsiveness.

LEADERSHIP

Battlefield stress in a nuclear environment will be higher than US forces have ever experienced. Only disciplined, well-trained, and physically fit units can function well in such an environment. Commanders who understand this and who provide soldiers with strong, positive leadership; good mental and physical preparation; and clear, comprehensive plans will ensure soldiers are in a better position to survive and win.

Units may have to operate with reduced mutual support and fire support, with degraded electronic communications abilities along extended lines of communications (LOC), and possibly without centralized control or continuous communications. Therefore, to improve command and control (C^2) leaders must work toward three general goals (which take on added importance in nuclear operations):

1. Instill an aggressiveness in their units that will transcend the shock and stress of the nuclear environment.
2. Train junior leaders to think and operate independently.
3. Develop small-unit cohesion.

Commanders and staffs must fully understand the potential of nuclear-weapons use by both an adversary and by a US joint force. They must also have a working knowledge of—

- Nuclear-weapons effects.
- Employment doctrine.
- Survivability measures necessary to preserve combat power.
- Medical requirements as a result of a nuclear explosion.
- The psychological impact of nuclear warfare on soldiers and units.

As commanders plan and fight successive battles involving actual or possible nuclear operations, they must continually assess their soldiers' psychological and physiological stresses. Commanders must emphasize situations in training, exercises, and leadership which will help soldiers accomplish their missions.

TRAINING

On a nuclear battlefield every soldier will confront new and strange circumstances and be under constant danger of attack. Nuclear weapons will quickly cause many casualties as well as intermediate and long-term radiation effects. Soldiers will be exposed to death and destruction of a magnitude far beyond imagination and may have to operate in widely dispersed, isolated, and semiindependent groups. Everyone must understand and practice survival and mitigation techniques. Such techniques will give soldiers direction and confidence in a confusing, frightening situation.

The large and sudden losses that a nuclear attack will cause will shock and confuse inadequately trained or psychologically unprepared troops. Reaction times will be slower, and the ability to respond to leadership and the desire to perform at peak proficiency may be degraded. The violence, stress, and confusion can easily divert attention from battlefield objectives. Extraordinary discipline and leadership are vital to overcoming distractions,

maintaining the mission's focus, and pressing the fight.

Training, the cornerstone of success, technically and psychologically prepares soldiers for the nuclear environment. Successful nuclear operations require expanded combat training that includes—

- Mitigation techniques against nuclear effects.
- Radiation monitoring.
- Decontamination techniques.
- Operations exploiting nuclear-weapons use.
- Recovering and regrouping after an attack.
- Handling mass casualties.
- Having to use degraded resources to accomplish the mission.
- Nominating nuclear targets.

Soldiers will fight as well or as poorly as they have been trained. Clear, concise policies and guidelines provide control and direction. Commanders must emphasize the fact that aggressive maneuver, even by relatively small units, will have a high probability of success in the confused aftermath of a nuclear attack.

NOTE: See FM 25-50 for in-depth discussions of these topics.

SUMMARY

This chapter describes the transition of joint nuclear doctrine to Army-oriented nuclear doctrine. A nuclear environment exists if either adversary in the conflict possesses nuclear capabilities. The levels of war clarify simultaneous activities Army forces conduct in the theater. Each level supports the next higher level of war.

The overall mission of military forces is to deter war—especially nuclear war. If deterrence fails, the US must be capable of deploying the forces necessary to defeat aggression, provide cohesion, and bring war to a speedy termination on terms favorable to the US and its allies.

The threat is worldwide regional instability (including possible use of nuclear weapons) coupled with the proliferation of weapons of mass destruction. Proliferation occurs when nations acquire and have the ability to use nuclear weapons against another nation. Nonproliferation activities attempt to prevent the spread of weapons of mass destruction. Counterproliferation centers on how to deter, defend, and attack against possible use of nuclear weapons.

In the event of either friendly or enemy nuclear-weapons use, commanders must provide soldiers with strong positive leadership, good mental and physical preparedness, and clear comprehensive plans. Positive leadership will ensure soldiers survive and win. Training is the cornerstone for success.

Enemy

Anticipating and planning against the effects of enemy nuclear-weapons use against friendly forces is critical to campaign design. Commanders must ask, "Does the enemy have nuclear capability?" If the answer is no, the question is moot. If the answer is yes, commanders must address issues such as dispersion, type, yield, delivery means, availability of weapons, doctrine, tactics, and the likelihood of use.

Troops

The number and type of troops available could greatly affect the tactical plan. Nuclear weapons can rapidly and decisively enhance combat power. Smaller forces possessing nuclear weapons can accomplish the mission of larger forces not possessing nuclear weapons. The unit's RES determines its fitness for duty. The lower the RES, the healthier the soldiers.

NOTE: See FM 3-3-1.

Terrain and Weather

Terrain and weather can affect nuclear-weapons operations and influence offensive maneuver. For example, tree blowdown in a heavily forested area would obstruct the forward movement of friendly forces.

Normally, tactical fallout will not be significant in a low air burst. However, weather conditions could cause rainout in the area of operations. Therefore, if rain or snow falls through a nuclear cloud, significant tactical fallout may occur. Rain and fog can also lessen the blast wave as it travels through dense air.

Time Available

Offensive actions become harder to conduct when the enemy has had time to organize his defense. The friendly commander can nominate nuclear weapons to effect surprise, prolong confusion, and sustain disorganization. Conversely, the nomination process can erode friendly units' available time because of the necessity of having to relay information and requests up through the chain of command and back down again.

CONDUCTING OFFENSIVE OPERATIONS

The commander plans and coordinates force movement in detail to avoid confusion and delay and to gain surprise. He concentrates his forces quickly, making maximum use of cover and concealment, signal security, and deception while avoiding or masking actions that would alert the enemy to the coming attack. He then conducts the attack rapidly and violently with concentrated firepower to disrupt enemy positions and hit deep in the enemy rear. Nuclear weapons can enhance and support such plans by providing—

- Destructive firepower. Nuclear weapons, even when limited, can help friendly forces cause great destruction of enemy positions with a minimum concentration of forces.
- Surprise. Because delivery of nuclear fires requires little visible unit preparation, surprise can be complete. However, OPSEC within the stockpile-to-target sequence is essential. Forces must avoid a great display of preparation before nuclear strikes to prevent the loss of surprise.
- Shock. Nuclear-weapons use disorganizes, demoralizes, and freezes enemy forces in place. However, these effects will only be temporary; exploitation must be immediate.
- Flexibility. As maneuver forces develop the situation, the commander can nominate nuclear weapons to develop a major operation. He might also substitute nuclear weapons for maneuver forces, allowing a smaller force to succeed in its attack against a stronger force.
- Obstacles. A nuclear weapon can alter terrain to create obstacles such as fallen trees, fires, craters, rubble, and radiation. This nearly instant creation of massive obstacles will allow a smaller force to succeed where a larger force might ordinarily be required. Creation of obstacles slows and canalizes counterattacks and denies terrain to the threat. But, like shock and surprise, obstacles are temporary. Conversely, obstacles can impede forward maneuver if the commander has not considered least-separation distances.

Nuclear weapons can provide the commander with a unique advantage. However, he equally

100-15 *Corps Operations.* This manual contains operational-level doctrine to corps commanders and staffs.

100-16 *Army Operational Support.*

100-17 *Mobilization, Deployment, Redeployment, Demobilization.*

Joint Publications (JP)

1-02 *Department of Defense Dictionary of Military and Associated Terms.*

3-12 *Doctrine for Joint Nuclear Operations.* This publication sets forth doctrine for the combatant commander to use for the conduct of joint nuclear operations. It guides the joint planning and employment of US nuclear forces.

3-12.1 *Doctrine for Joint Nonstrategic Nuclear Weapons Employment.* This publication provides guidance for nuclear-weapons employment. Doctrine and guidance apply to the commander of combatant commands, subordinate unified commands, joint task forces, and subordinate components of these commands.

3-12.2 (SRD) *Nuclear Weapons Employment and Effects Data* (U). This publication sets forth doctrine and selected TTP for joint operations and training. It is the accepted joint standard for nuclear target analysis, employment procedures, and the source for nuclear effects data.

3-12.3 *Nuclear Weapons Employment and Effects Data.*

Department of Defense Nuclear Agency Effects Manuals (DNA EM)

1 (SRD) Chapter 10 Electromagnetic Pulse.

Chapter 14 Effects of Personnel.

Chapter 15 Damage to Structures.

Chapter 17 Damage to Military Field Equipment.

Chapter 21 Damage to Missiles.

NOTE: DNA is now known as the Defense Special Weapons Agency (DWA).

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand this publication.

Allied Tactical Publications (ATP)

35A *Land Force Tactical Doctrine.* This publication establishes common NATO doctrine for the use of land force commanders in military operations when NATO forces are placed under their command.

Robert Scheer

WITH ENOUGH SHOVELS: Reagan, Bush & Nuclear War

"Dig a hole, cover it with a couple of doors and then throw three feet of dirt on top... It's the dirt that does it... if there are enough shovels to go around, everybody's going to make it."

—T. K. Jones, Deputy Under Secretary of Defense for Strategic and Theater Nuclear Forces

"President Ronald Reagan had been in office less than a year when he approved a secret plan for the United States to prevail in a protracted nuclear war. This secret plan, outlined in a so-called National Security Decision Document, committed the United States for the first time to the idea that a global nuclear war can be won."

With these words Robert Scheer, the distinguished national reporter for the *Los Angeles Times*, begins this astonishing revelation of how a handful of Cold War ideologues—led by the President himself—have reversed the longstanding American assumption that nuclear war means mutual suicide.

Scheer reveals that President Reagan finds it "ridiculous" to assume that nuclear war means mutual destruction.

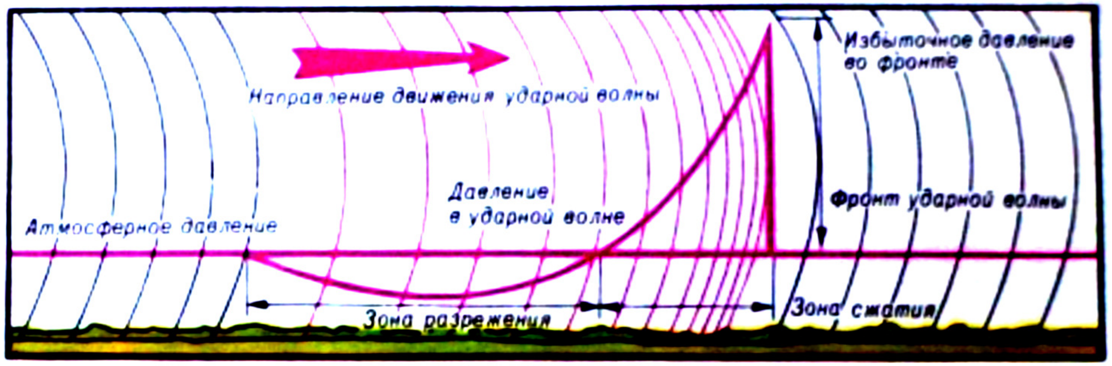
Robert Scheer's aim in *With Enough Shovels* is to expose the deadly course on which we are now embarked, a course that categorically rejects the strategic assumptions that prevailed from Presidents Eisenhower through Carter and that sustained the Nixon-Kissinger program of détente—a program which our current leaders call "appeasement." Instead they have chosen to pursue nuclear brinksmanship. As Richard Perle, the man whom President Reagan appointed Assistant Secretary of Defense for International Security Policy, told Scheer, "I've always worried less about what would happen in an actual nuclear exchange than the effect that the nuclear balance has on our willingness to take risks in local situations."

ROBERT SCHEER is a national reporter for the *Los Angeles Times* and has also written frequently for *Esquire*, the *Washington Post* and *Playboy*, where he conducted the interview in which Jimmy Carter revealed the lust in his heart.

УДАРНАЯ ВОЛНА

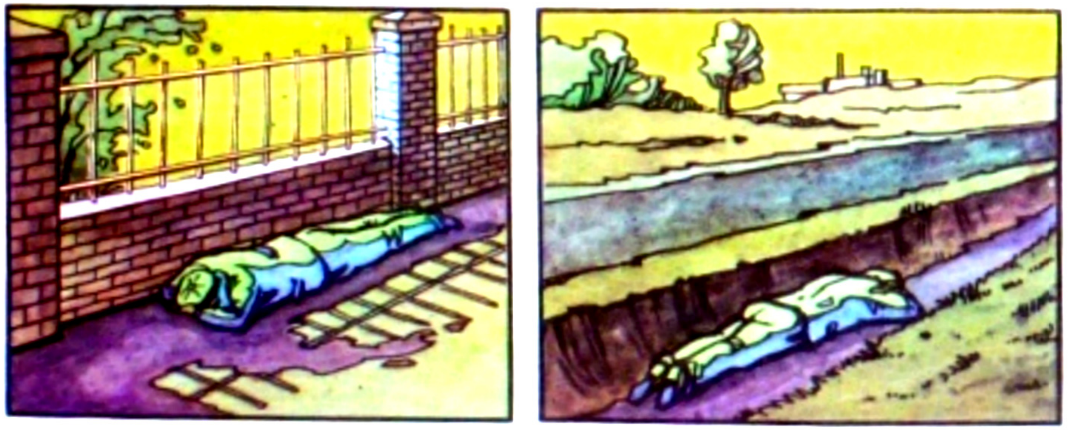
УДАРНАЯ ВОЛНА ЯВЛЯЕТСЯ ОСНОВНЫМ ПОРАЖАЮЩИМ ФАКТОРОМ ЯДЕРНОГО ВЗРЫВА. ОНА ВЫЗЫВАЕТ РАЗЛИЧНЫЕ ПО ХАРАКТЕРУ И ТЯЖЕСТИ ПОРАЖЕНИЯ ЛЮДЕЙ И ЖИВОТНЫХ, РАЗРУШАЕТ ЗДАНИЯ, СООРУЖЕНИЯ. С УДАЛЕНИЕМ ОТ ЦЕНТРА (ЭПИЦЕНТРА) ВЗРЫВА РАЗРУШИТЕЛЬНАЯ СИЛА УДАРНОЙ ВОЛНЫ ОСЛАБЕВАЕТ

СТЕПЕНЬ ПОРАЖЕНИЯ И РАЗРУШЕНИЯ УДАРНОЙ ВОЛНОЙ ЗАВИСИТ ОТ МОЩНОСТИ БОЕПРИПАСА, ВИДА И РАССТОЯНИЯ ОТ ЦЕНТРА (ЭПИЦЕНТРА) ВЗРЫВА, КОНСТРУКЦИИ И РАСПОЛОЖЕНИЯ ЗДАНИЙ И СООРУЖЕНИЙ, ПОЛОЖЕНИЯ ЛЮДЕЙ, ТЕХНИКИ ВО ВРЕМЯ ВОЗДЕЙСТВИЯ УДАРНОЙ ВОЛНЫ, РЕЛЬЕФА МЕСТНОСТИ И ДРУГИХ ФАКТОРОВ

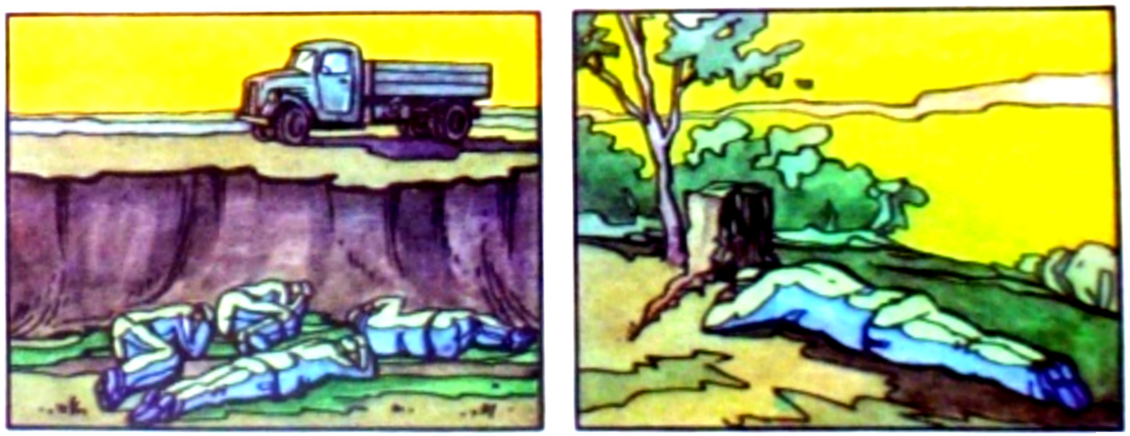


Ударная волна представляет собой область резкого сжатия воздуха, распространяющегося со сверхзвуковой скоростью во все стороны от центра взрыва

Очаг ядерного поражения в зависимости от давления во фронте ударной волны условно делится на зоны разрушений



Убежища защищают от воздействия ударной волны, а укрытия ослабляют ее воздействие



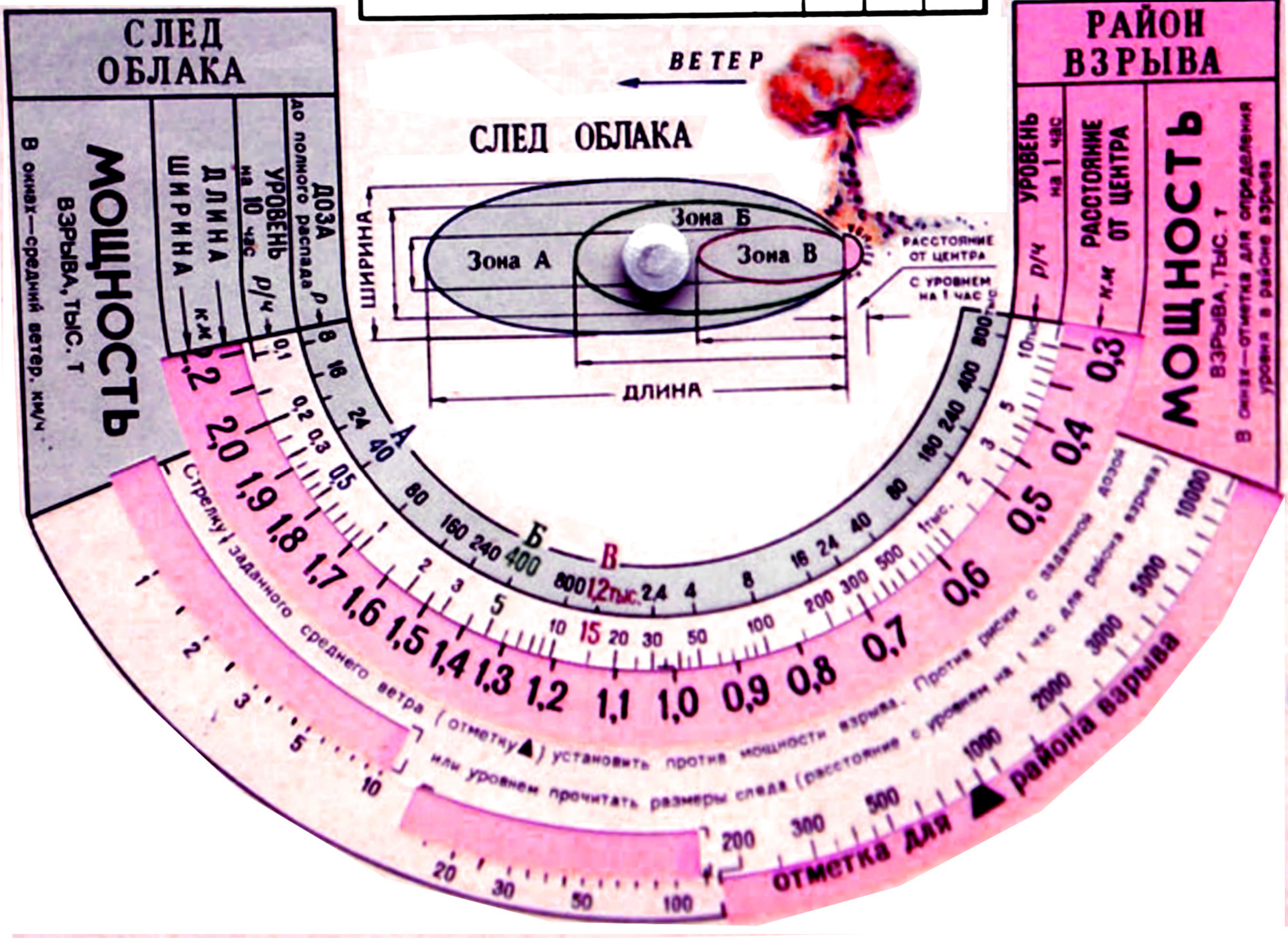
На значительном расстоянии от места взрыва защитой могут служить рельеф местности и местные предметы

ЛИНЕИКА РЛ

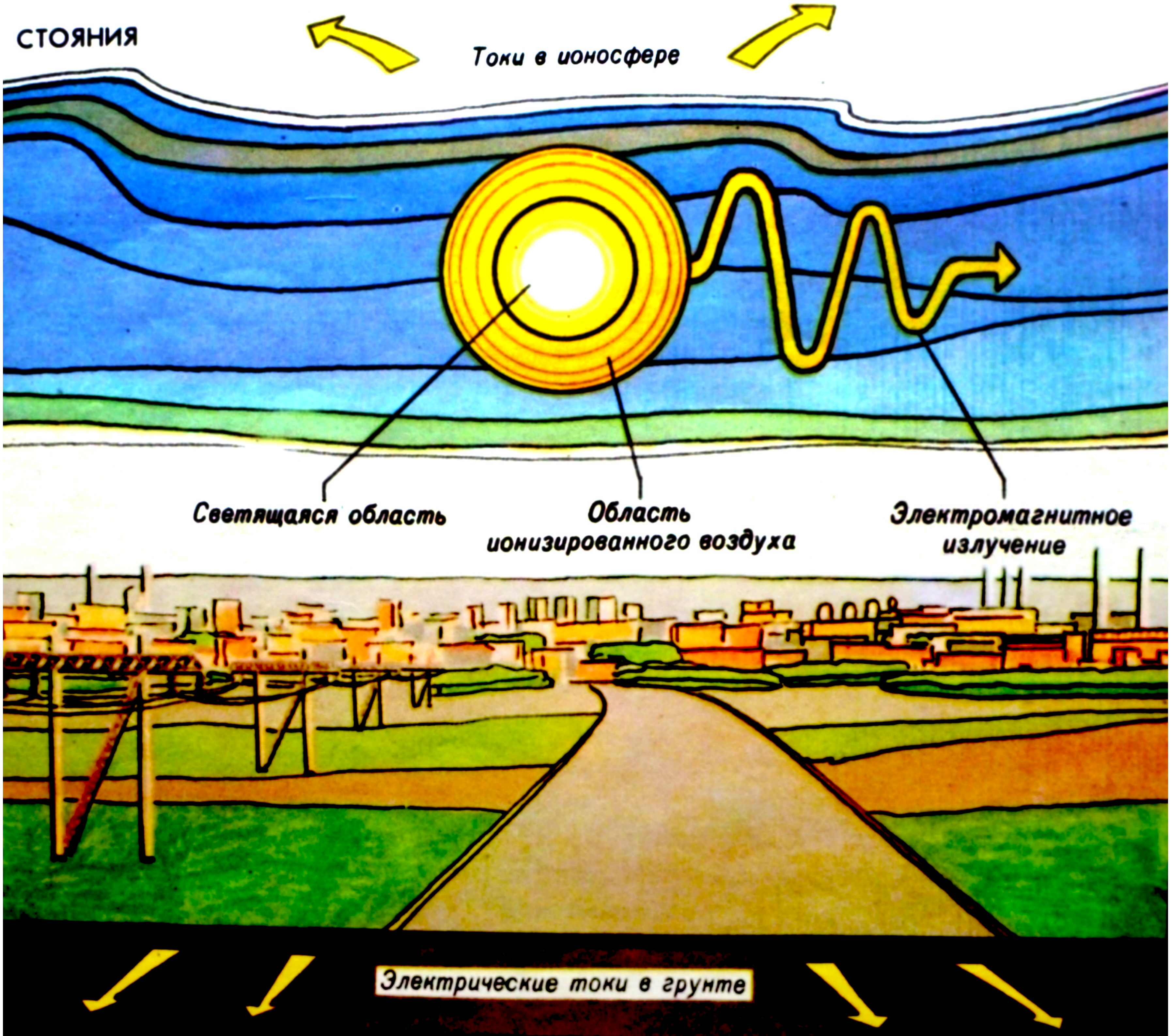
ДЛЯ ОЦЕНКИ РАДИАЦИОННОЙ ОБСТАНОВКИ ПРИ НАЗЕМНЫХ ВЗРЫВАХ

ТАБЛ 1 ХАРАКТЕРИСТИКИ ЗОН ЗАРАЖЕНИЯ ПО СЛЕДУ ОБЛАКА
(НА ВНЕШНИХ ГРАНИЦАХ)

ПОКАЗАТЕЛИ	ЗОНЫ		
	А	Б	В
ДОЗЫ ДО ПОЛНОГО РАСПАДА, р	40	400	1200
СРЕДНИЕ УРОВНИ РАДИАЦИИ, р/ч НА 10 ЧАСОВ ПОСЛЕ ВЗРЫВА	0,5	5	15



СТОЯНИЯ

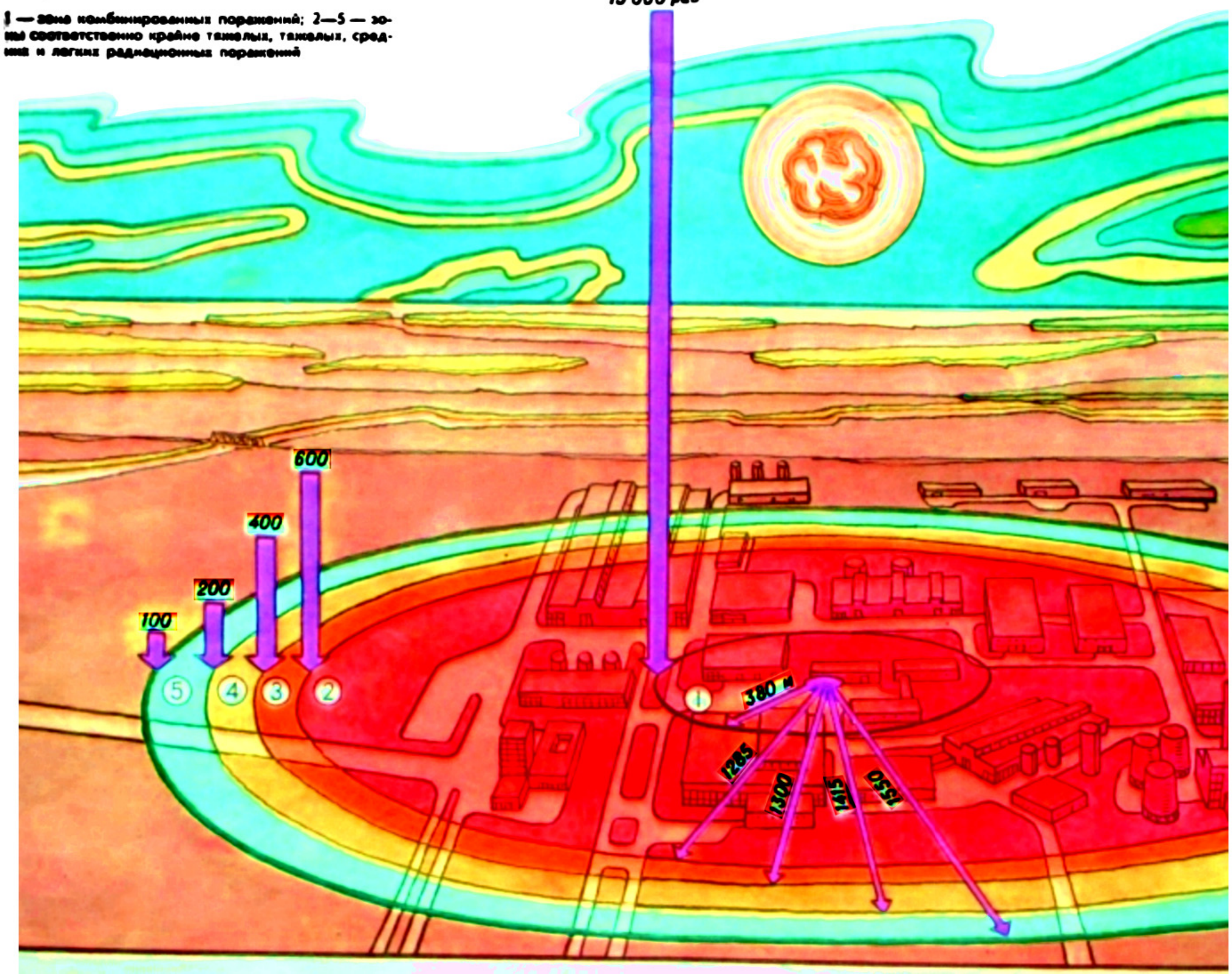

Токи в ионосфере
Светящаяся область
Область ионизированного воздуха
Электромагнитное излучение
Электрические токи в грунте

НЕЙТРОННОЕ ОРУЖИЕ И ОСОБЕННОСТИ ЗАЩИТЫ ОТ НЕГО

НЕЙТРОННОЕ ОРУЖИЕ — ЭТО НЕЙТРОННЫЕ БОЕПРИПАСЫ И СРЕДСТВА ДОСТАВКИ ИХ К ЦЕЛИ. **НЕЙТРОННЫЙ** БОЕПРИПАС — ТЕРМОЯДЕРНЫЙ ЗАРЯД СВЕРХМАЛОЙ МОЩНОСТИ (0,5—2,0 кт), ДЕЙСТВИЕ ЕГО ОСНОВАНО НА РЕАКЦИИ СИНТЕЗА НУКЛИДОВ ВОДОРОДА — ДЕЙТЕРИЯ И ТРИТИЯ

Очаг поражения при взрыве нейтронного боеприпаса мощностью 1 кт

1 — зона комбинированных поражений; 2—5 — зоны соответственно крайне тяжелых, тяжелых, средних и легких радиационных поражений

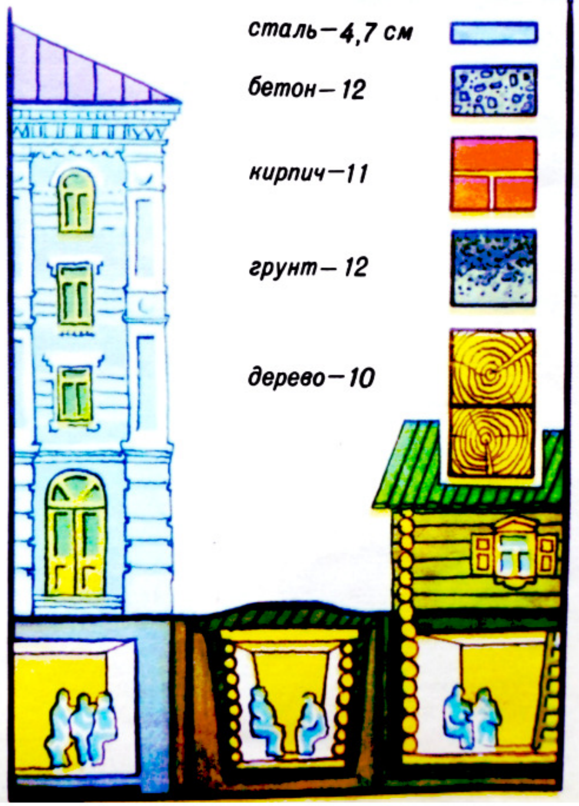


РАСПРЕДЕЛЕНИЕ ЭНЕРГИИ ВЗРЫВА НЕЙТРОННОГО И ЯДЕРНОГО БОЕПРИПАСА

Поражающий фактор	Энергия боеприпаса, % нейтронного	Энергия боеприпаса, % ядерного
Ударная волна	40	50
Световое излучение	30	35
Проникающая радиация	25	5
Радиоактивное заражение	5	10

ЗАЩИТНЫЕ СВОЙСТВА МАТЕРИАЛОВ

Экспозиционную дозу радиации ослабляют вдвое материалы толщиной



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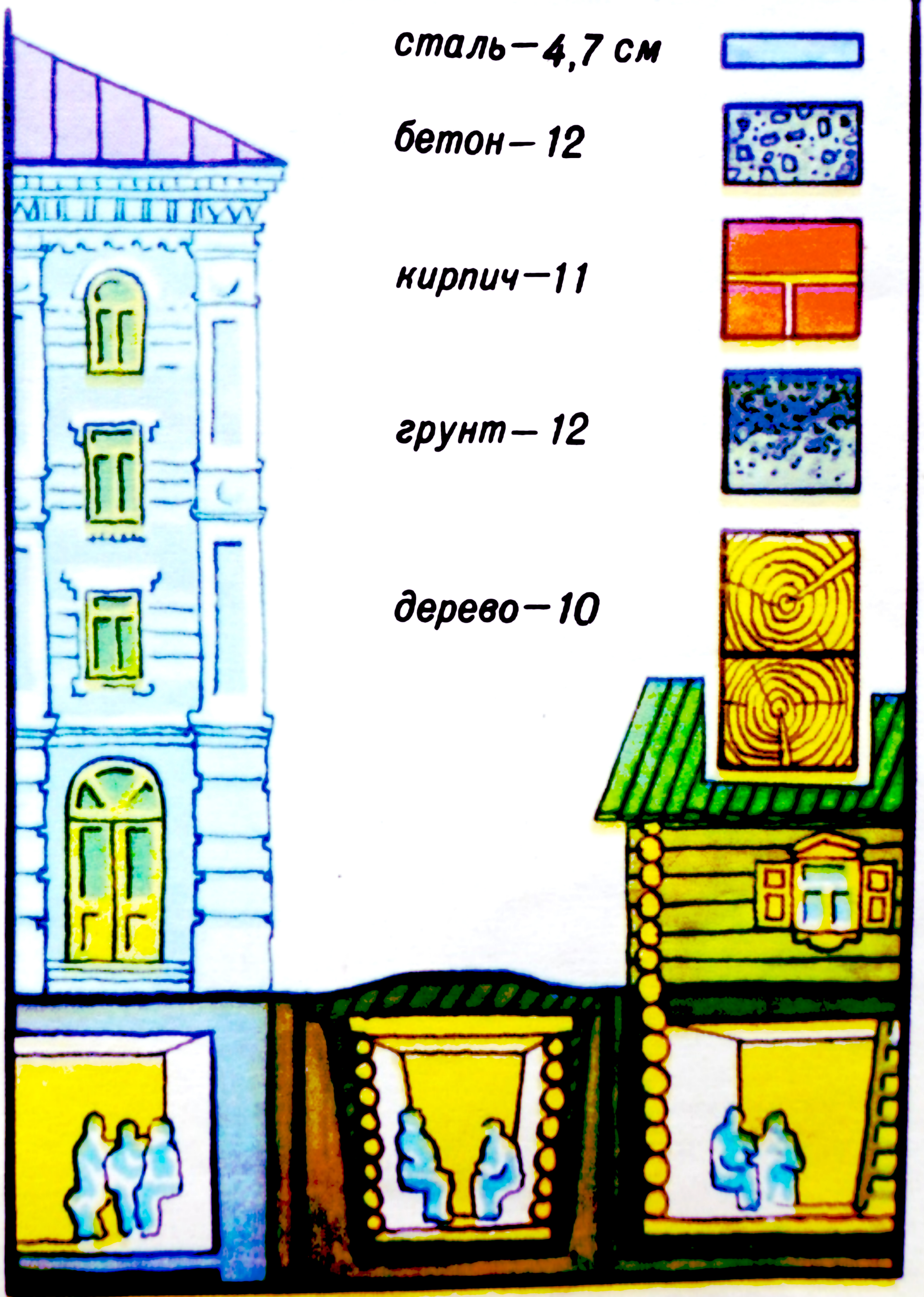

CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

HEARINGS

BEFORE THE

JOINT COMMITTEE ON DEFENSE PRODUCTION CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

SECOND SESSION

APRIL 28, 1976

Printed for the use of the
Joint Committee on Defense Production

U.S. GOVERNMENT PRINTING OFFICE
74-307 WASHINGTON : 1976

HEARING ON CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

WEDNESDAY APRIL 28, 1976

U.S. SENATE AND
U.S. HOUSE OF REPRESENTATIVES,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

The committee met at 10:05 a.m. in room 5302, Dirksen Senate Office Building, Hon. William Proxmire, vice chairman of the subcommittee, presiding.

Present: Senators William Proxmire and John Sparkman.

Senator PROXMIRE. The committee will come to order.

Today's hearing inaugurates a review by the Joint Committee on our Nation's civil preparedness. It is the first such congressional review in over two decades.

By civil preparedness, we mean those mainly civilian measures by which we seek to protect the lives and property of our citizens.

This is the first function of any government. A government which cannot meet this fundamental test of defending its people and the national treasure is not likely to survive for very long.

In subsequent hearings, the committee will examine the adequacy of Federal, State, and local preparedness programs, including plans for fallout shelters, strategic evacuation, preparedness exercises and drills, civil defense stockpiles, and continuity of government. Likewise, the Joint Committee will inquire into the organization of the Government for preparedness. It will also review the Nation's industrial and economic preparedness in terms of the defense industrial base.

This is an especially timely undertaking. Over the past 2 years the United States has been moving from a declared nuclear policy of mutual assured destruction to one of flexible response, or limited nuclear war.

In the minds of some eminent strategists, this implies a lowering of the nuclear weapons threshold, a quickening of the trigger finger on the missile launch console, and an increased probability of uncontrolled nuclear conflict.

But to other equally qualified experts, this shift in strategic doctrine, this shift to larger numbers of more flexible, or more versatile and accurate weapons and control systems does not undermine deterrence of nuclear war; instead, it enhances deterrence.

Well, it can't be both ways and whenever you have such a complete divergence in expert opinion, it is time for a careful review of the facts.

These hearings are also timely in that there are increasing rumors of a civil defense gap, with the Soviet Union well in the lead.

In this year's annual report, Defense Secretary Rumsfeld stated that, and I quote:

An asymmetry has developed over the years that bears directly on our strategic relationship with the Soviets and on the credibility of our deterrent posture. For a number of years, the Soviets have devoted considerable resources to their civil defense effort which emphasizes the extensive evacuation of urban populations prior to the outbreak of hostilities, the construction of shelters in outlying areas, and compulsory training in civil defense for well over half the Soviet population. The importance the Soviets attach to this program at present is indicated not only by the resources they have been willing to incur in its support, but also by the appointment of a deputy minister of defense to head this effort.

Now, the term "asymmetry" used by the Secretary sounds to a non-expert like me like a four-bit word for "gap." We have heard a great deal over the years about gaps that never materialized or proved unimportant. Yet we have spent a lot of money to eliminate the nonexistent or the insignificant. It is for this reason that the committee last week published the declassified text of the 1957 Gaither Report which invented the first missile gap.

STATEMENT OF HON. PAUL NITZE, FORMER SECRETARY OF THE NAVY, DEPUTY SECRETARY OF DEFENSE, AND MEMBER OF THE SALT DELEGATION

Mr. Nitze. Mr. Chairman, my interest in the questions which this committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next 2 years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the survey, as Vice Chairman, I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

At Hiroshima and Nagasaki there was no air-raid warning and very few people availed themselves of the crude civil defense facilities which were available. Most of those that did, even at ground zero, in other words, directly under the explosion, which was at the optimum height of burst, survived. The trains were operating through Hiroshima 2 days after the explosion.

Let me paraphrase from an interchange I had in 1960 with Colonel Lincoln, head of the faculty at West Point, on this subject:

The Russians are careful students of Clausewitz. I do not believe they would ever ignore either the danger that a war once started might escalate to the full violence which the pure theory of war might indicate; on the other hand, they would never forget that war is a tool of policy and that every effort must be made to avoid letting it so escalate.[1]

[1] In this connection the following quotation from *Communist of the Armed Forces* in November 1975 is pertinent: "The premise of Marxism-Leninism on war as a continuation of policy by military means remains true in an atmosphere of fundamental changes in military matters. The attempt of certain bourgeois ideologists to prove that nuclear missile weapons leave war outside the framework of policy and that nuclear war moves beyond the control of policy, ceases to be an instrument of policy and does not constitute its continuation is theoretically incorrect and politically reactionary."

On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

In conclusion, I would like to comment on this committee's print containing the Gaither Report of 1957.

I have now read that report for the first time in nearly 20 years. I am impressed—especially in light of the information then available to the Gaither committee—by the care and comprehensiveness of that committee's examination of the problems assigned to it for study. I note in contrast the cavalier imprecision reflected in the foreword prepared by this committee's staff.

It is not true that the Gaither Report ignored arms control, nor is it true that the report spoke of U.S. strategic inferiority as then a fact. To the contrary, the Gaither Report described the United States as then "capable of making a decisive attack on the U.S.S.R." In view of SAC's vulnerability "to a surprise attack in a period of lessened world tension," the Gaither Report also noted the U.S.S.R.'s capability to make "a very destructive attack on this country."

The report then observed, "As soon as SAC acquires an effective 'alert' status, the United States will be able to carry out a decisive attack even if surprised," and it anticipated that juncture "as the best time to negotiate from strength, since the U.S. military position vis-a-vis Russia might never be so strong again."

In attempting to disparage the Gaither committee's analysis, the staff foreword cites a subsequent estimate "* * * that at the time of the Gaither Report the Soviet Union probably had fewer than a dozen operational ICBMs." In fact, at the time of the Gaither Report—only a few weeks after the sputnik launching—the Soviet Union obviously had no operational ICBMs. The Gaither Report made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the U.S. Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions.

Summary Statement by the Honorable Paul H. Nitze

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I believe they will always pay close attention to the interrelationship of the offense and the defense and not ignore either side of the equation. I cannot believe they would so ignore the military core of war as to consider the type of controlled nuclear conflict discussed in some of the papers circulated by the Committee's staff where military targets are avoided and industrial targets are hit. On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

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The Gaither Report focused attention on those questions. Thereby the Report became a factor in stimulating an enormous effort on the part of the U.S. to move ahead with pertinent strategic programs. In those years the rate of expenditure on strategic programs was, allowing for inflation, about two and a half times the present rate. For all the great expense, the program was a bargain when considered against the calamitous potential consequences of permitting the strategic relationship to become unstable to the detriment of U.S. security and with increased risk to the maintenance of peace.

The Report placed first priority on the military measures necessary to maintain strategic stability and high quality deterrence. It placed a lower priority on those measures necessary to ensure survivability of the population in event deterrence were to fail. The two classes of measures are, however, interrelated.

STATEMENT OF HERMAN KAHN, DIRECTOR, HUDSON INSTITUTE

Senator PROXMIRE. Mr. Kahn.

Mr. KAHN. It is customary to start one's testimony with a statement of qualifications. Let me instead start with a disqualification.

I haven't really been spending very much time in the military field since 1965, but I started to go back last year, and I am now in the middle of reacquainting myself with the issues.

I might say though that comparing today's discussion to the sixties, there has been very little substantial improvement. In fact there have been some retrogressions. This both disturbs and surprises me.

Let me start by agreeing with Paul on two issues. The chairman just stated we can't have both increased and decreased deterrence. I believe that there are many measures which can go in both directions.

There are many measures which increase deterrence in one scenario or context, and decrease deterrence in another scenario or context. In particular, if one focuses on this abstract war, what Paul referred to as a pure military war, or a surprise attack out of the blue directed against civilians, then it is terribly easy to do many things which will decrease that deterrence.

But since I tend to feel we have, relatively speaking, too much deterrence of this situation I do not object to decreasing the deterrence of surprise attack out of the blue in favor of increasing deterrence in other situations. In fact there has been much too much attention to this simple situation. I know back in 1960, a number of polls were taken by Tom Schelling, by Weapon Systems Evaluation Group (WSEG) and others. In these polls analysts were asked "If a war occurred, what scenario do you think would have preceded the war?"

Almost universally, they agreed there would have been a very tense situation, say bombs bursting in Europe, and then either an attack by the Soviets because they got into serious trouble, an accidental war, or an attack by the U.S. All the analysts agreed that a surprise attack out of the blue, directed at cities, was far and away the least probable way that a war was likely to start.

And yet they all also agreed that 90 percent of their personal studies and effort went to that case and the other 10 percent or so went into a study of a surprise attack out of the blue which hit military bases. In other words, the analysts agreed, that even though they were able

to choose their own subjects of study, they were spending almost all of their time on scenarios which, in their judgment, were not probable or important. They simply were the easiest things to study and talk about.

[Additional remarks:]

Many analysts are still doing this, but do not seem to know that this emphasis distorts the realistic priorities.

Now, when we looked at civil defense in 1960—or today—it was really almost impossible to protect the population against a surprise attack directed against them. We found that it was also impossible to protect an economic base for massive war production against a surprise attack directed against the economic base.

Therefore, we did not ask ourselves, as a high priority, what does civil defense do for these objectives in these scenarios.

However we did not stop there. We went on to ask ourselves if there were any other roles for civil defense.

It seemed to us that there were a large number of roles. All of them tended to be second or third priority but still terribly important. When people said, "But that doesn't do any good in the first priority situation," we answered, "We don't care."

The first, perhaps the most important role, is to protect people when they are not targets. I am prepared to believe that doing this decreases deterrence, but I am willing to do it anyway.

I know when I examine the problem of attacking the Soviet Union that I want to preserve Moscow and Leningrad, my two biggest assets, and anything they do to make Moscow and Leningrad safe from becoming bonus targets improves my ability to plan war against the Soviets. Moscow and Leningrad are important to the Soviets and they are probably willing to do that. Deterrence is not the sole objective of policy.

In a book called *On Thermonuclear War* which I published in 1960, we mentioned what we called the Doomsday Machine was the highest possible deterrent, yet nobody wanted it. I might also mention that I made clear, in that book, that we didn't think there was any missile gap. In fact, just to go back over a little history of that, most people's recollection of the debate of that period tends to be wrong.

It is not true that the Democrats raised the issue of a missile gap against the Republican administration. That was a Republican statement. The Republicans predicted the Russians would have 300 missiles by 1960. But at the same time, the Republican administration said this wouldn't make any difference, because we had 2,000 bombers and they were more important than 300 missiles.

The great contribution of the Gaither Report, as Paul just said, was to make clear that if the Soviets had 300 missiles and we did not have any kind of warning system, then we might not have 2,000 bombers, because they could be destroyed by a surprise attack while still on the ground.

I also made clear, that while the Soviets probably would not have 300 operational missiles in 1960, if they did have them, we would be in trouble—that is, despite the predictions by the Republican administration we did not think they had such a force—but we were not sure.

What does one do when the other side may be able to do something in the near future and if one waits until he is certain before reacting, it is too late, while if one reacts early it may turn out to have been unnecessary?

Let me also make a remark about a release I saw from this committee which listed a series of predicted gaps which did not occur. In at least half the cases, people were rather clear that the gap might not occur, but they were not sure.

[Additional remarks:]

But they felt they had to worry about it ahead of time and even make some preparations because they could not afford to wait until all the facts were in.

Let me ask a question: What do you do if the other side exhibits a weapon system and has the production capability? You are not quite sure what he is going to do. Do you wait until he does it or do you worry about it?

In general this is a very complicated issue. In some cases, we almost have to make preparations ahead of time, even though they may be wasted. In other cases, we should wait until we are more sure; in still other cases, one just hopes for luck. But one should not, in my judgment, downgrade responsible officials who get concerned under such circumstances.

I might also draw attention to some studies done by Albert Wohlstetter. It is pointed out in these studies that in most cases, we have underestimated rather than overestimated U.S.S.R. future capability. I will ask that this report be sent to the committee.

If you look at the record, there has been more a problem of underestimation than overestimation. This is true in terms of the number of missiles the Soviets have had over time and in terms of Soviet capability on all kinds of other issues. We tend to remember the discussion when some hysterical people overstate the problem; then it turns out to be wrong. I would argue this is not at all the characteristic problem.

Let me turn to the major point I wanted to make today. I would argue that the scenario I worry about as the most probable scenario, is also the scenario which is least discussed. This is the case where there is opportunity for significant or even all-out mobilization before major thermonuclear attacks against the cities occur.

There are two recent and useful historical examples which illustrate this concept, the Korean War and World War II.

In June 1950, Congress was debating whether the budget should be $15, $16 or $17 billion. The previous year it had been $13 billion. A number of distinguished witnesses testified that $18 billion would strain the economy, but $16 billion was all right. North Korea marched on South Korea, and within 1 year, Congress authorized $60 billion, an increase by a factor of 4.

This was totally unexpected and totally changed the strategic problem. One should note that it would not have been possible to fit into even an $18 billion budget hardly any of the weapons systems we have procured since World War II. One could not have bought a Sage system, a B–47 system, a B–52 system, a Nike Hercules system, a Polaris system, and so on. None of these systems would have been feasible at the $5 or $6 billion budgets per service which were, roughly, current at that time.

As a result of this authorization, the Air Force budget was increased by about a factor of 5. The other two services had an increase of about 3. As a result, a whole new range of possibilities opened up for the services.

I can easily envisage a scenario for crisis in the future which involves military budgets of $500 billion or more. That would change, if you will, the whole character of strategic planning. I do not expect any such situations to arise with high probability, but I do not consider it paranoia or unwise to prepare for such situations.

Probably an even better prototype for the situation we are thinking about is pre-World War II. After World War I, much of the world became sick of war, and war became "unthinkable" to most people, particularly in the victorious "Allied Powers." Strategists and publicists talked about poison gas and knock-out blows; they thought all the capital cities would be destroyed by poison gas in the first few days of a war. They did not understand the idea of limitations in warfare—of mutual deterrence even after hostilities have broken out.

When Hitler got elected in 1933, people became interested in larger defense budgets. Then he marched into the Rhineland and, of course, defense budgets increased slightly. Then there was the Anschlus and then Munich, and more substantial increases in military budgets. With the invasion of Czechoslovakia, everybody got deeply concerned. Then, finally, there was the invasion of Poland, the formal declaration of war and then 7 months of more or less "phony war." As a result there was opportunity on both sides for 7 months' of full-time war production, before the war really opened up.

We would argue that similar possibilities should be considered today. Nobody is interested in jumping into a nuclear war today. Nobody is going to want to execute the usual picture of nuclear war, in which each side presses every button and goes home. It is extraordinarily difficult to believe such a scenario.

It might happen. But I would be willing to bet, if this were a betting matter, 50 to 1 against it.

On the other hand, the situation might arise in which there was a declaration of war, followed by a phony war, or a serious confrontation in which there were credible threats of war. By the way, in such a confrontation, the following dialog tends to occur.

Both sides are saying to the other side, "There is absolutely nothing at risk which justifies this terrible danger to which we are subjecting each other and the rest of the world. It is clear that whatever we are arguing about is simply not worth the risk of a thermonuclear war. Therefore, one of us has to be reasonable—and it isn't going to be me."

That is, by the way, a terribly persuasive argument.

At this point, each side is trying to explain why the other side should be reasonable. You don't have to have a great defense to do that. All you have to be able to do is say, "I believe my defense establishment is better than yours, in important ways."

I can imagine the Russians telling us. "You are telling us the money we spent on our defense establishment does us no good, but we spent it because we thought it does do good. We believe that this defense establishment of ours works. You don't, but we believe it does."

If you can get that point across, you are going to put great pressure on the other side to back down.

Senator PROXMIRE. Very strong chance of what? I missed that.

Mr. KAHN. If we believe that they believe they have confidence in their establishment, we are going to back down, whether or not their

confidence is justified, because we would be destroyed almost as much as a result of their mistaken belief as by a correct one. If the other man can give you a credible picture, that he believes he has a serious edge over you, then even if he does not objectively have that edge, you may be in trouble.

That is even more true for allies. If they think the other side believes it has an edge, the allies are going to hedge. Finally it is even more true for neutrals that in a bargaining situation the strategic balance is very complex (which should be an obvious point) and the outsider is likely to be excessively influenced by appearances. Who strikes first and how many are dead in each city are almost irrelevant to many of these issues.

Finally, a last point. When we write scenarios for nuclear war, we find it difficult to write a credible scenario which doesn't involve months or weeks of warning. I would guess we are as good at writing scenarios as anybody in the world. We have certainly written as many.

I want to warn the committee, on the other hand, that when we looked at World War I, we didn't find that scenario plausible. The mere fact we can't write a plausible scenario for a war doesn't mean it can't occur, because one can find historical examples to the contrary.

Nevertheless, every scenario we write for nuclear war involves days, weeks or months of tension. Evacuation, last moment mobilizations are extraordinarily possible. By the way, evacuations occur not as a result of secret intelligence or in any attempt to try to outrun the missiles or the bombers. The *New York Times* and the *Washington Post* provide the warning perhaps days before the attack. People or governments then get frightened and decide to decrease their vulnerability to attack. The idea is, can you exploit such warning if it is printed in the papers?

[Complete statement follows:]

SUMMARY PAPER AND BRIEFING NOTES ON THE POTENTIAL OF THE DEFENSE MOBILIZATION BASE CONCEPT BY HERMAN KAHN, WILLIAM BROWN, AND WILLIAM SCHNEIDER, JR.

This submission is the responsibility of the authors and is not to be construed as representing any official opinions of the Hudson Institute or any other associated individuals or agencies.

PREFATORY NOTE

The following paper represents a summary of studies developed by the staff and consultants of the Hudson Institute more or less continuously over the last fifteen years although naturally it focuses more intensively upon recent work—in particular, a summary of a report on the concept of mobilization warfare by Herman Kahn and William Schneider, Jr. Most of Hudson's program of civil defense and mobilization base studies has been accomplished under the direction of William Brown, Herman Kahn and William Schneider, Jr. and at least half the Institute's personnel have participated in one or more of them. This particular submission was prepared as a joint paper by the three people named above.

MOBILIZATION WARFARE

1. The concept of mobilization warfare

The notion of mobilization in a nuclear age has the appearance of a contradiction in terms when arrayed against the conventional concept of mobilization. Mobilization has in general, been associated with the redirection of national resources, both human and material away from traditional civilian pursuits to support a defense effort. To some extent, it has been possible to conceive of a limited mobilization of military forces and associated national resources to support

limited political objectives although the more traditional perception has been associated with a general mobilization of the entire industrial might and armed forces of a nation.

The possibility of intercontinental strategic nuclear attack made possible through the development of ICBM's, missile firing submarines, and long-range bombers have made the initiation and conclusion of a nuclear conflict appear to be a matter of hours or days, and certainly not more than a few weeks in duration, making the traditional notion of mobilization appear to be as archaic and obsolete as the forces and weapons that had been in the past, mobilized.

This study is intended to advance the concept that mobilization is an important component of strategic nuclear conflict, and, we will argue, is likely to be the prototype of any U.S.-Soviet nuclear conflict should such a conflict occur. The concept can be most simply characterized from the perspective of the following simple generalized scenario: During a period of intense political crisis between the U.S. and the Soviet Union, both sides fear that a nuclear war may actually occur. However, neither side is willing to risk the consequences of a nuclear war with the existing levels of forces and defenses (military and civilian). As a consequence, each of the parties attempts to develop on a frantic basis, a very large-scale effective nuclear offense and defense capability which is associated with genuine fears about the possibility of a general war. The period of mobilization during and after an intense political crisis characterizes what we describe as "mobilization warfare." It is warfare in the sense of an intense and bitter competition of an accelerated arms race, but without the certainty that direct military action will occur. A plausible outcome of this scenario is that the side which mobilizes most effectively within a relatively brief period of time (say six months to two years) can achieve a dominant position capable of inhibiting the diplomatic efforts of the other.

The notion of "mobilization warfare" is not restricted only to strategic nuclear warfare. It is also applicable, for example, to a U.S.-Soviet struggle in Europe in which an intense political crisis raises the specter of an outbreak of conventional warfare between the two nations without the expectation that such a conflict would lead to a strategic or tactical nuclear exchange.

Perhaps the closest parallel to mobilization warfare during the nuclear era arose as a consequence of the Korean war. The ominous character of Soviet foreign policy following World War II culminated in the Soviet sponsored attack of North Korean forces against the Republic of Korea. The direction in Soviet foreign policy after World War II was not offset by any rebuilding of U.S. military power which had been rapidly dismantled after the end of World War II. However, when the Soviets authorized the attack on Korea, the change in U.S. attitudes regarding preparedness for a U.S.-Soviet strategic nuclear contingency was electric. One measure of the character of this concern, a measure characteristic of a serious mobilization, was the decision of the Congress to increase annual defense expenditures from $16 to the $60 billion authorized after the outbreak of the Korean war. This vast increase in authorized expenditure made possible a set of strategic programs that were simply not feasible within the prior U.S. defense budget. The new authorization made possible the B–52, the B–47, the Polaris Program, and Atlas Program and a host of related technological initiatives whose consequences are still influencing the shape of the U.S. strategic program today. It also developed a reasonable (for the time) civil defense program designed to move the more vulnerable portions of the home population rapidly to safer areas. As a consequence of this enormous build-up of strategic nuclear capability arising out of the concern over a possible U.S.-Soviet nuclear conflict in the early 1950s, the United States achieved for more than a decade a stark nuclear superiority over the Soviets. This superiority was so vast that in retrospect it appears clear that the Soviets were almost totally deterred from attempts to exert military power in support of their diplomatic objectives throughout the late 1950s and early 1960s.

In the early 1950s the Soviets also attempted to develop a larger strategic program, but were much less successful than the United States. This form of mobilization warfare, we argue, is more likely to become a "standard" mode of nuclear conflict with the Soviet Union than the commonly anticipated mode, namely a large-scale exchange of nuclear weapons.

Perhaps the most significant difference between traditional mobilization concepts and the concept of "mobilization warfare" that is the focus of this paper is that in a modern mobilization, the adequacy of a period of mobilization may be "tested" only in the sense that it can affect the perceptions of an opponent without

a shot being exchanged. Moreover, the period of mobilization in the modern era might be considerably more compressed and complicated than any which we have experienced in this century. In a very practical sense, the mobilization of Germany and the allied powers before the first World War was a traditional process which extended over a period of many years, although the most intense efforts took place after the initiation of the conflict. Similarly, the German and Japanese pre-war mobilization of their forces occurred over many years. In both cases, a large-scale and protracted conflict followed. Under modern conditions, a nuclear conflict between major powers is likely to be short compared to previous conflicts or to any period of mobilization.

The concept of mobilization warfare in a nuclear era implies relatively short reaction times with the ability to deploy major offensive as well as active and passive defensive systems which may be extremely costly and complex by any prior standards. Under such circumstances, it is entirely plausible that the U.S. strategic budget alone could constitute an expenditure of several hundreds of billions of dollars per year. Expenditures at such huge levels make possible a very wide range of military and non-military defense systems that could not be seriously considered with recent strategic budgets—less than $10 billion.

For example, potentially high grade missile defense systems employing lasers, particle beam technology and other advanced concepts for boost phase, mid-course, and terminal interception could, in principle, be procured under conditions of "mobilization warfare." The crucial determinants for acquiring such a capability lies in the prior research and development program and in proper institutional orientation toward a mobilization potential. The requirements of a "mobilization base" to support the notion of mobilization warfare is sufficiently different from the objectives of existing research and development needed to support current and near-term defense requirements that expenditures for a mobilization base should be partitioned from other R&D expenditures. The primary function of a mobilization base is to facilitate the shortening of lead times to procure highly effective strategic forces, active defenses, and civilian protection, should a decision to procure such a capability be made in a context that requires such a build-up be completed in an extraordinarily short period of time (short, that is, by the standards of recent experience). Under some circumstances, it is sufficient simply to have "paper plans" say, for the conversion of designated industrial potential from civilian to military uses. In other cases, where the requirements are more critical, and less easily adaptable to short-term changes, some limited development or prototyping may be necessary. In still other cases, particularly where the function is highly complex and likely to involve large numbers of both civilian and military personnel, such as an ABM or civil defense system, it may be necessary to conduct a limited deployment or field testing, and to develop the professional cadres who could support a vast expansion if and when circumstances require such expansion. The decision as to what elements of a potential U.S. strategic posture should be most extensively or rapidly developed would depend upon the contribution such efforts would make to reducing the lead times necessary to deploy the capability during a period of intense mobilization. The United States already possesses a substantial infrastructure for the rapid short-term expansion of U.S. strategic forces. With relatively modest expenditures, it should be possible to dramatically improve the ability of the United States to mobilize rapidly during an appropriate crisis to increase strategic nuclear forces, its active and passive defenses, and its general purpose forces without the protracted lead times that we have tended to become accustomed to over the past two decades.

2. A baseline mobilization warfare scenario

The implausibility of a U.S.-Soviet strategic nuclear exchange in recent politico-military circumstances has tended to obscure the fact that there are numerous possibilities for a major clash of interests between the superpowers; and consequently, for escalation.

The scenario proposed here arises out of the Achilles' heel of the Soviet Union, the behavior of their East European satellites, in this case, East Germany. Internal dissension develops beyond the control of the local and Soviet political and military leadership in East Germany to the point where large-scale border crossing into West Germany by deserting elements of East German armed forces involve the NATO nations. Unlike the standard escalation scenario where such events lead ultimately to a U.S.-Soviet nuclear exchange, the potential escalation, itself, becomes a force for restraint.

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TYPICAL STRATEGIC MOBILIZATION SCENARIOS

Of the four scenarios given below, the first two are history, the third used to be the great fear of NATO, and the fourth is probably the great fear of the Warsaw Pact.

1. The "phony war," 1940 (5 months):
(a) Pre-crisis arms competition (UK, France, Germany and the U.S.S.R.).
(b) A major series of political-military crisis—
Militarization of the Rhineland (1936);
Anschluss (Austria) (1938);
Sudeten crisis (1938–39);
War in Poland (1939).
(c) De-escalation and negotiation (antagonists began a rapid buildup fearing a resumption of full scale conflict).

2. Korea (1950–53):
(a) Pre-war politico-military crises—
Soviet invasion of Iran (1946);
Soviet takeover of East European nations (1945–48);
Berlin blockade (1948);
Soviet intervention in Turkey and Greece;
Soviet military buildup, post WW-II.
(b) Major turnabout in U.S. policy—
Factor of four increase in defense expenditures in 18 months;
Massive emphasis on strategic preparedness, especially active defense.

3. Successful Soviet attack on W. Berlin and subsequent de-escalation.
4. Uprising in East Germany gets out of control and escalates.

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CHARACTERISTICS OF A SPECIAL MOBILIZATION SCENARIO: A FORMAL DECLARATION OF WAR BY THE U.S.

1. The declaration would have solemn and especially great significance for our enemies, allies, and neutrals.
2. The information transferred would have:
(a) Unambiguous factual content of great importance;
(b) Undeniable implications and symbolism;
(c) Highly uncertain interpretations or implications.
3. Its existence would preempt "ordinary" crisis negotiation and deny the stability of any recent *fait accompli*.
4. In some extreme crises it could be temporizing—a declaration is not a spasm response—and lead to deescalation of actual fighting.
5. But it implies a rapid response to any increased use of force.
6. It tends to force a decision by allies to cooperate actively.
7. It would justify many peripheral actions (blockades, interdiction, property confiscation, internment of hostile aliens, etc.).
8. It would tend to unify the national response—and increase defense spending enormously through mobilization.
9. It would convey the unambiguous message that a *formal* peace treaty will be required to settle all the important issues.

ROLE OF RESEARCH FOR MOBILIZING ACTIVE DEFENSES

1. Missile defense probably would be the most important and expensive effort.
2. Lead-time reduction becomes extremely important.
3. A program is required to facilitate rapid massive procurement of mutually reinforcing systems—
Boost phase interception;
Mid course interception;
Terminal interception.
4. A capability may soon be needed to support a war in space.
5. A capability is required for integration into other—high priority strategic mobilization programs—
Air defense;
Civil defense.
Major research objective: design systems which are highly effective, mutually supporting and which can be rapidly deployed at high levels of expenditure.

APPENDIX I

PAUL HENRY NITZE

In the spring of 1969, Paul Henry Nitze was appointed the representative of the Secretary of Defense to the United States Delegation to the Strategic Arms Limitation Talks with the Soviet Union; a position he held until June 1974, at which time he resigned.

Mr. Nitze resigned from his duties as Deputy Secretary of Defense on January 20, 1969, a position he had held since July 1, 1967, succeeding Cyrus R. Vance.

Mr. Nitze was serving as 57th Secretary of the Navy when he was nominated by former President Lyndon B. Johnson on June 10, 1967, to become Deputy Secretary of Defense. He was confirmed by the United States Senate on June 29, 1967.

The late President John F. Kennedy nominated Mr. Nitze to be Secretary of the Navy on October 14, 1963. At that time he was serving as Assistant Secretary of Defense (International Security Affairs), having assumed that position on January 29, 1961. He began his duties as Secretary of the Navy on November 29, 1963.

Graduated "cum laude" in 1928 from Harvard University, Mr. Nitze subsequently joined the New York investment banking firm of Dillon Read and Company. In 1941, he left his position as Vice President of that firm to become financial director of the Office of the Coordinator of Inter-American Affairs.

From 1942–1943, he was Chief of the Metals and Minerals Branch of the Board of Economic Warfare, until named as Director of Foreign Procurement and Development for the Foreign Economic Administration.

During the period 1944–1946, Mr. Nitze was Vice Chairman of the United States Strategic Bombing Survey. He was awarded the Medal of Merit by President Truman for service to the nation in this capacity.

For the next seven years, he served with the Department of State, beginning in the position of Deputy Director of the Office of International Trade Policy. In 1948, he was named Deputy to the Assistant Secretary of State for Economic Affairs. In August, 1949, he became Deputy Director of the State Department's Policy Planning Staff, and Director the following year.

Mr. Nitze left the federal government in 1953 to become President of the Foreign Service Educational Foundation in Washington, D.C., a position he held until January 1961.

Mr. Nitze is Chairman of the Advisory Council of The Johns Hopkins School of Advanced International Studies in Washington, D.C., and also serves on the Board of Trustees of the University. He holds memberships on the Board of Directors of Schroders, Inc., in New York, and Schroders, Ltd., in London, The American Security and Trust Company of Washington, D.C., Northwestern Mutual Life Mortgage and Realty Investors of Milwaukee, Wisconsin, and is Chairman of the Board of the Aspen Skiing Corporation.

HERMAN KAHN

Herman Kahn was born in Bayonne, New Jersey, in 1922. He received a B.A. from UCLA in 1945 and an M.S. in physics from the California Institute of Technology in 1948. He was associated with the Rand Corporation before becoming in 1961 the principal founder and director of the Hudson Institute, a research organization studying public policy issues, with headquarters in Croton-on-Hudson, N.Y. His international reputation as a strategic warfare analyst or, as the *New Republic* put it, one of "the prophets of strategic reality," is based on his work at the Institute and on his books: *On Thermonuclear War* (1960), *Thinking about the Unthinkable* (1962), *On Escalation* (1965 and, revised Pelican

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Statement of E. P. Wigner [1] for the Joint Committee on Defense Production

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

THE EFFECTIVENESS OF CIVIL DEFENSE

This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the U.S. Atomic Energy Commission.

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Are the U.S.S.R. and China the only countries with elaborate and well developed civil defense systems? No—most of the peace-loving countries also have such systems, based on blast shelters, and their yearly expenditures per person on such defense is about 15 times greater than ours. This has been, so far, about 40¢ per person a year. Incidentally, the Swiss civil defense repeats our President Kennedy's message: (Civil defense) "is insurance we trust, will never be needed"—its greatest accomplishment is, according to the Swiss, that it will *not* have to be used, that it will divert the aggressive instincts of possible opponents.

It is easy to conclude that an effective civil defense is not only desirable, it is also possible.

IS CIVIL DEFENSE NECESSARY?

What is the principal danger that threatens us in the present absence of an effective civil defense? It is the possibility of the U.S.S.R. evacuating its cities, dispersing their population, and then making demands on us, under the threat of a nuclear attack, approximating those made by Hitler or Czechoslovakia which led to the Munich pact. This left Czechoslovakia essentially defenseless.

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THE ARGUMENTS AGAINST CIVIL DEFENSE

The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort. One of the two arguments we now hear, the civil defense is too expensive, seems almost ridiculous. If Switzerland, Sweden, etc., *even China*, can afford the more costly, the blast shelter method, we with the highest per capita national wealth, can also surely afford the defense of our people. The other argument, in the words of one of the most learned opponents of civil defense, S. Drell, is that it would lead to an "escalation of the apprehension from the mood of today, vis-a-vis the dangers of a nuclear exchange between the U.S. and the Soviet Union." Should the apprehension of the danger not be greater now, where we have no effective defense, than it would be when we have such defense? Or is it proposed that we should lull the common people into ignorance of the true situation? It is remarkable also that the U.S.S.R. is not criticised for fostering the "apprehension" of its own people. One must conclude that the varying arguments against civil defense have little validity.

A FEW PROPOSALS RELATED TO OUR DEFENSE

The first change I would advocate is to stop maintaining that a nuclear war would be the end of mankind. Such a statement may give the impression to an opponent that he can achieve anything by threatening with a nuclear war. After all, he would argue, the opponent (that is us) will make any sacrifice to avoid the "end of mankind". Hence, if he is threatened with extinction he will give in, particularly if the threat comes from a party which does not believe that the war precipitated by him will lead to the "end of mankind". Instead of such a blatantly incorrect statement, it would be better to subscribe to Chuykov's doctrine that "knowledge and the skillful use of modern protective measures" will make it possible to provide effective protection. At least, we could adhere to Kissinger's earlier (1957) statement: "While it (civil defense) cannot avert the traumatic effect of vast physical destruction, its efficient operation may make the difference between the survival of a society and its collapse."

The second measure which I consider to be urgent is to establish better contact with the people at large. This makes it desirable for DCPA to expand its staff by the employment of people who can establish a contact with the population at large, who can speak and write the truth convincingly. One of the functions of these advisors would be to help the high schools to give instruction on the nature of nuclear explosions and the defense against the effects of these. This is a subject which is foreign to most present high school teachers, and the advisor could and should help them to acquire the necessary knowledge. After all, the Federal Government now intends to support the local schools and can well suggest that these contribute to the protection of the country. The high school instruction on civil defense—obligatory in the U.S.S.R.—would be very useful since, after all, we learn best when we are young and we learn most non-elementary facts from our teachers. But even more generally, the establishment of a close contact between those who protect our freedom, and those whose freedom is protected, would be very desirable; and acquainting people at large with the methods and effectiveness of civil defense would provide an avenue toward this goal. It may not be easy to find people who know about the methods and effectiveness of civil defense and who are also able and interested in communicating this and much other knowledge to the people at large, but every effort should be made to find such people and support them.

The last suggestion I wish to make is that the DCPA budget should certainly not be cut. It should steadily be increased until, in a few years, it reaches the per capita level of other peace-loving and non-expansionist countries, such as Switzerland, Holland, Sweden, etc. For reasons given in the rest of my statement, this would be of decisive importance for maintaining a valid, widely endorsed, and vigorous defense effort for our country—and it would support all freedom-directed nations. Their independence does depend to a certain degree on our strength and our ability to stand up for them. The examples of Hungary, Czechoslovakia, Poland—to mention only a few—show that such independence does not come freely.

Let me end on a bit more hopeful tone which is, however, as sincere as was the rest of my statement. This is the hope that an effective civil defense may not only protect our country and our freedoms, but it may

also lead to a more true peace than the present one, which is based on the fear of destruction. I hope such a peace in which no rulers are tempted to increase their domains will come into being!

Statement of Gerard C. Smith [1]

I propose to discuss this morning some of the arms control implications of Vladivostok as well as certain related aspects of the current Defense budget submission.

I. THE VLADIVOSTOK ACCORD

At the start let me say that I put forward these ideas tentatively, not categorically. I question that anyone can speak with certainty about the slippery issues surrounding strategic arms and their control. I admit to a bias in favor of a very strong defense but I believe that arms control can also advance the security of the United States and the world whether or not there is some relaxation of tensions between the U.S. and the U.S.S.R.

The Vladivostok accord should not be judged in and of itself—but in connection with the limit on defensive systems (ABMs) agreed upon in 1972 and other American-Soviet agreements relating to arms control. It may help in judging the significance of Vladivostok to see that accord as part of a process that has been going on for more than five years. The general strategic dialog of the 1960s led to the specific SALT exchanges of 1969–72 at Helsinki, Vienna, Washington, and Moscow. Gradually the two sides developed somewhat better understanding of each other's strategic preoccupations. Concerns about accidental or miscalculated nuclear hostilities led to the first two SALT agreements in 1971—on measures to reduce the risk of outbreak of nuclear war and on measures to improve the Washington-Moscow direct communication link or "Hot Line." In 1972 there was the major breakthrough, the treaty limiting ABMs to two sites apiece, accompanied by the interim agreement to freeze offensive launches at the approximate levels of 1972. These were followed in 1973 by the Nixon-Brezhnev agreed principles for offensive arms limitation and in 1974 the ABM Treaty levels were reduced to one site apiece. At year's end the Vladivostok accord foreshadowed limitations on offensive systems which although of relatively short duration may be considered as a counterpart of the ABM Treaty. In judging this latest agreement one should consider the cumulative effect of the entire SALT process which hopefully can be considered as a preparatory stage for the natural next steps—reduction in offensive force levels which the sides are now committed to negotiate and some limitation on improvements in weapons characteristics. A total ban on ABM systems should also be reconsidered.

I would not favor interrupting the current Geneva negotiations by introducing a proposal for reductions. I do not believe that reductions are negotiable now. The Soviet position since 1968 has called for first a limitation and subsequently for reductions. When and if

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[1] Mr. Smith is the former Director of the U.S. Arms Control and Disarmament Agency and chief U.S. representative in SALT I. He is now in private practice with the law firm of Wilmer, Cutler, and Pickering. His statement submitted to the Joint Committee was originally delivered to the Senate Foreign Relations Committee in April 1975.

(Gross exaggerations, assuming Nevada desert type terrain with no thermal shadows by city skylines, no duck and cover, no clothing and fraudulent blast effects data which ignores Hiroshima's evidence)

APPENDIX III

U.S. CIVILIAN NUCLEAR FATALITY ESTIMATES [1] FOR VARIOUS COUNTERFORCE ATTACK SCENARIOS

Type of attack	Assumptions	Estimated fatalities
Comprehensive attack:		
Case 1, 60 percent destruction of military targets.	1 optimum height of burst and 1 surface burst warhead per each of 1,054 ICBM silos; pattern attack of SAC bases: unspecified attack on 2 SSBN support bases; good shelter posture.	3, 200, 000
Case 2, 60 percent destruction of military targets.	2 optimum height of burst warheads per each of 1,054 ICBM silos; no pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; poor shelter posture.	6, 700, 000
Case 3, 57–60 percent destruction of military targets.	2 surface burst warheads per each of 1,054 ICBM silos; pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; very poor shelter posture.	16, 300, 000
ICBM only attack:		
Case 1	2 550 kt optimum height of burst warheads per each of 1,054 ICBM silos.	[2] 4, 000, 000
Case 2, 42 percent silo destruction.	1 550 kt surface burst and 1 550 kt optimum height of burst warhead per each of 1,054 ICBM silos.	5, 600, 000
Case 3, 80 percent silo destruction.	1 3 Mt surface burst and 1 3 Mt optimum height of burst warhead per each of 1,054 ICBM silos.	18, 300, 000
Case 4	2 3 Mt surface burst warheads per each of 1,054 ICBM silos	[3] 20, 000, 000
Airlift attack: [4]		
Case 1	1 200 kt cruise missile warhead per each of 5 U.S. heavy airlift bases (Dover AFB, Del.; McGuire AFB, N.J.; Travis AFB, Calif.; Charleston AFB, S.C.; and McChord AFB, Wash.)	70, 000
Case 2	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases	210, 000
Case 3	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases uses offset targeting.	135, 000

[1] Department of Defense estimates as reported to the Senate Foreign Relations Committee, July 11, 1975, and published in "Analyses of Effects of Limited Nuclear War," pp. 12–24. Note that figures are fatalities only and not casualties and that attacks are restricted to military facilities (counterforce) rather than populated areas (countervalue). Shelter posture is a function of degree of hardening and the willingness of the population to use shelters.

[2] Under.

[3] Circa.

[4] Assumes allied victories in a European war supported by U.S. military airlift provide incentives for destruction of major American airlift centers.

Survival of the Relocated Population of the U.S. After a Nuclear Attack

FINAL REPORT • JUNE 1976 ORNL-5041

by
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OAK RIDGE NATIONAL LABORATORY

ADA026362

SURVIVAL OF THE RELOCATED POPULATION OF THE U.S. AFTER A NUCLEAR ATTACK

C. M. Haaland, C. V. Chester, and E. P. Wigner

ABSTRACT

The feasibility of continued survival after a hypothetical nuclear attack is evaluated for people relocated from high-risk areas during the crisis period before the attack. The attack consists of 6559 MT, of which 5951 MT are ground bursts, on military, industrial, and urban targets. Relocated people are assumed to be adequately protected from fallout radiation by shelters of various kinds. The major problems in the postattack situation will be the control of exposure to fallout radiation, and prevention of severe food shortages to several tens of millions of people. A reserve of several million additional dosimeters is recommended to provide control of radiation exposure. Written instructions should be provided with each on their use and the evaluation of the hazard. Adequate food reserve exists in the U.S. in the form of grain stocks, but a vigorous shipping program would have to be initiated within two or three weeks after the attack to avoid large scale starvation in some areas. If the attack occurred in June when crops on the average are the most vulnerable to fallout radiation, the crop yield could be reduced by about one-third to one-half, and the effects on crops of possible increased ultraviolet radiation resulting from ozone layer depletion by nuclear detonations may further increase the loss. About 80% of the U.S. crude refining capacity and nearly all oil pipelines would be either destroyed or inoperative during the first several weeks after an attack. However, a few billion gallons of diesel fuel and gasoline would survive in tank storage throughout the country, more than enough for trains and trucks to accomplish the grain shipments required for survival. Results of a computer program to minimize the ton-miles of shipments of grain between Business Economic Areas (BEAs) indicate that less than 2% of the 1970 rail shipping capacity, or less than 6% of the 1970 truck shipping capacity would be adequate to carry out the necessary grain shipments. The continuity of a strong federal government throughout the attack and postattack period is essential to coordinate the wide-scale interstate survival activities.

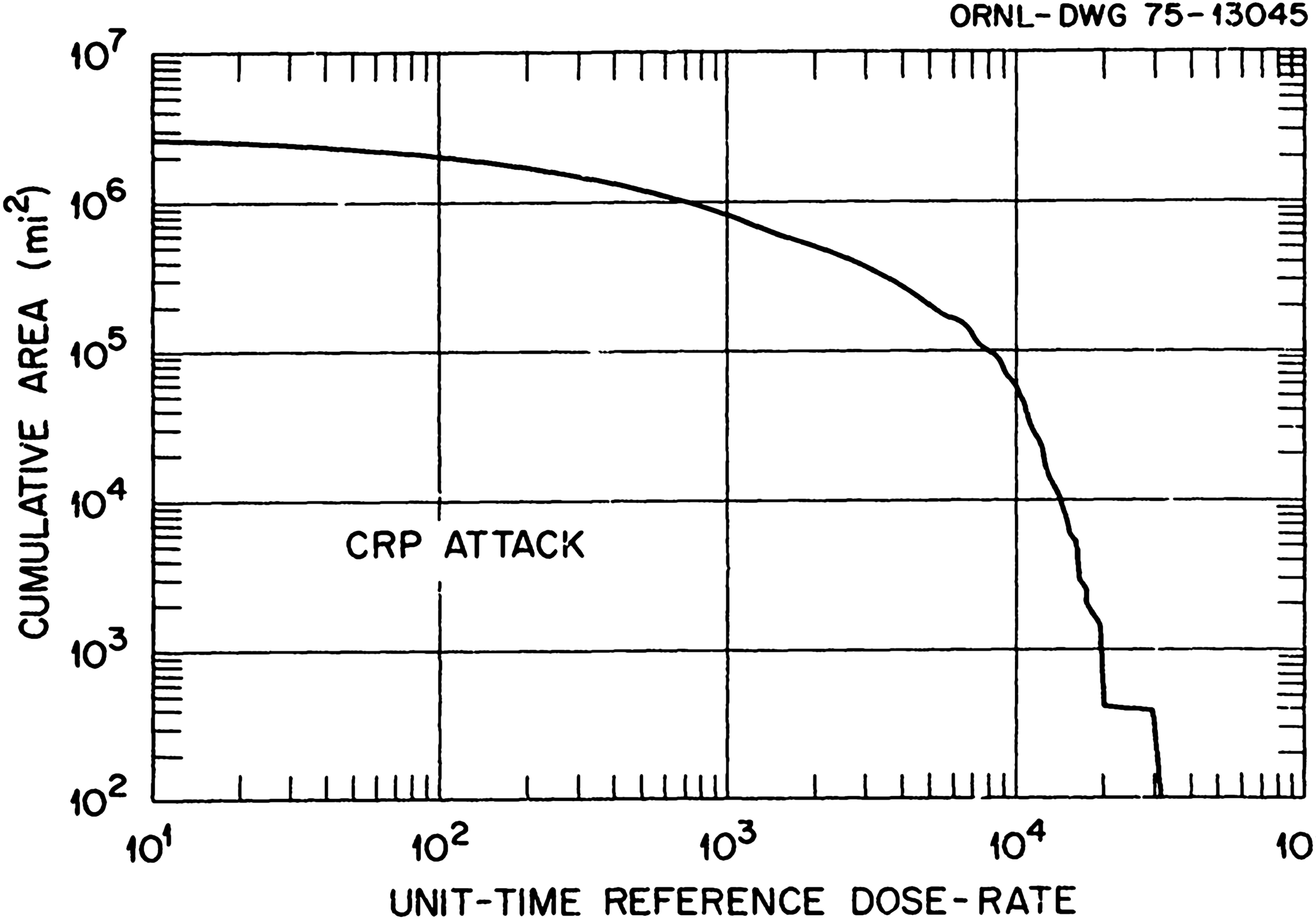

Fig. 4.2 Area of U.S. as a Function of Unit-Time Reference Dose Rate.

Environmental Radiation Protection Factors
Provided by Civilian Vehicles

Vehicle	Position	Protection Factor Range
Commercial bus (common type)	Throughout bus	1.5-2.0
Commercial bus (scenic cruiser type)	Throughout bus	1.5-2.0
School bus	Throughout bus	1.5-1.8
Passenger car	Passenger side (chest)	1.5-1.7
	Driver side	1.5-1.7
Pickup	Driver side	1.9-2.1
Crew cab	Driver side	1.8-2.0
	Back seat	1.8-2.0
Carryall	Driver side	1.7-1.9
	Rear side	1.7-1.9
2-1/2-ton truck	Driver side	1.8-2.0
	Center of bed	1.4-1.6
5-ton truck	Driver side	2.0-2.2
	Sleeper	1.9-2.1
Heavy Truck	Driver side	1.4-1.6
	Center of trailer	2.7-3.1
Fire truck	Driver side	2.7-3.1
	Standing area in back	1.6-1.8
Switch engine	Engineer's seat	3.0-3.5
Railway guard car	Sleeping quarters	2.2-2.6
	Kitchen area	2.4-2.8
	Center area	2.0-2.4
Heavy locomotive	Engineer's seat	3.0-3.5

SOURCE: Z. G. Burson, "Environmental and Fallout Gamma Radiation Protection Factors Provided by Civilian Vehicles," Health Physics, 26, 41-44, 1974.

THE WHITE HOUSE

WASHINGTON

~~TOP SECRET/SENSITIVE~~ July 25, 1980

#76

Presidential Directive/NSC-59

TO: The Vice President
The Secretary of Defense

ALSO: The Assistant to the President for National Security Affairs
The Chairman, Joint Chiefs of Staff

SUBJECT: Nuclear Weapons Employment Policy (C)

In PD-18, I directed a follow-on study of our targeting policy for nuclear forces. I have reviewed the results and considered their implications for maintaining deterrence in the present decade, particularly in light of the growing Soviet strategic weapons arsenal and its capabilities. (S)

The most fundamental objective of our strategic policy remains nuclear deterrence. I reaffirm the directive of PD-18 to that effect. The purpose of this directive is to outline policies and actions in the nuclear force employment field to secure that continuing objective. (S)

Our strategic nuclear forces must be able to deter nuclear attacks not only on our own country but also on our forces overseas, as well as on our friends and allies, and to contribute to deterrence of non-nuclear attacks. To continue to deter in an era of strategic nuclear equivalence, it is necessary to have nuclear (as well as conventional) forces such that in considering aggression against our interests any adversary would recognize that no plausible outcome would represent a victory on any plausible definition of victory. To this end and so as to preserve the possibility of bargaining effectively to terminate the war on acceptable terms that are as favorable as practical, if deterrence fails initially, we must be capable of fighting successfully so that the adversary would not achieve his war aims and would suffer costs that are unacceptable, or in any event greater than his gains, from having initiated an attack. (C)

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Case 2008-085

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NARA [illegible] Date 7/24/12

The employment of nuclear forces must be effectively related to operations of our general purpose forces. Our doctrines for the use of forces in nuclear conflict must insure that we can pursue specific policy objectives selected by the National Command Authorities at that time, from general guidelines established in advance. (S)

These requirements form the broad outline of our evolving countervailing strategy. To meet these requirements, improvements should be made to our forces, their supporting C3 and intelligence, and their employment plans and planning apparatus, to achieve a high degree of flexibility, enduring survivability, and adequate performance in the face of enemy actions. The following principles and goals should guide your efforts in making these improvements. (S)

Pre-planned options. The Single Integrated Operational Plan will provide pre-planned targeting for strikes against the Soviet Union, its allies and its forces. It should provide for retaliatory strikes that will be effective, even if the Soviets attack first, without warning, and in a manner designed to reduce our capability as much as possible. It will be developed with flexible sub-options that will permit, to the extent that survival of C3 allows, sequential selection of attacks from among a full range of military targets, indistrial targets providing immediate military support, and political control targets, while retaining a survivable and enduring capability that is sufficient to attack a broader set of urban and industrial targets. In addition, to the maximum extent possible, pre-planned options will be provided for selection in response to specific, lesser contingencies (including attacks on Cuba, SRV and North Korea as appropriate). [redacted]

While it will remain our policy not to rely on launching nuclear weapons on warning that an attack has begun, appropriate pre-planning, especially for ICBMs that are vulnerable to a preemptive attack, will be undertaken to provide the President the option of so launching. (TS)

Flexibility. In addition to pre-planned options we need an ability to design nuclear employment plans on short notice in response to the latest and changing circumstances. This capability must be comprehensive enough to allow rapid construction of plans that integrate strategic force employment with theater nuclear force employment and general purpose force employment for achieving theater campaign objectives and other national objectives when pre-planned response options are not judged suitable in the circumstances. (S)

To assure that we can design such plans, our goal should be to have the following capabilities on a continuing basis in peacetime, during crises, and during protracted conflict:

-- Staff capabilities, within all unified and specified commands which have nuclear forces, to develop operational plans on short notice and based on the latest intelligence.

-- Staff capabilities at the seat of Government to support the NCA for coordinating and integrating the nuclear force employment for all commands.

-- Intelligence and target development capabilities which permit damage assessment and acquisition of a broad range of targets, fixed and mobile, on a timely basis for military operations. (S)

Reserve Forces. Pre-planned options should be capable of execution while leaving a substantial force in secure reserve and capable of being withheld for possible subsequent use. The forces designated for the reserve should be the most survivable and enduring strategic systems consistent with the need for a flexible and varied reserve force capable of being effectively employed against a wide target spectrum and withheld if necessary for a prolonged period. The secure reserve force will be increased over the next two years to support a more flexible execution of our countervailing strategy. This will be done according to the Secretary of Defense's guidance. (TS)

Targeting categories. Overall targeting planning appropriate to implement a countervailing strategy will result in a capability to choose to put the major weight of the initial response on military and control targets. Military targets must be selected for the purpose of destroying enemy forces or their ability to carry out military operations. Strategic and theater nuclear forces should to the extent feasible be used in combination with, and in support of, general purpose forces to achieve that objective. (S)

More specifically, the following categories of military targets, with appropriate sub-options for different theaters, should be covered in planning:

-- strategic and theater nuclear forces, including nuclear weapons storage;

-- military command, control, communications, and intelligence capabilities;

-- all other military forces, stationary and mobile;

-- industrial facilities which provide immediate support to military operations during wartime. (TS)

In addition, pre-planned options, capable of relatively prolonged withhold or of prompt execution, should be provided for attacks on the political control system and on general industrial capacity. (TS)

There must be extensive and effective coverage in the pre-planned options of all categories. Methods of attack on particular targets should be chosen to limit collateral damage to urban areas, general

industry and population targets outside these categories, consistent with effectively covering the objective target, and, where appropriate, overall plans should include the option of withholds to limit such collateral damage. (TS)

Command, Control and Communications, and Intelligence. Flexibility in contingency planning and in operations will be highly dependent on our C^3I capabilities, including their ability to acquire targets, assess damage, and survive attack. Strategic stability in an era of essential equivalence depends as much on survivability, endurance and reconstitutability of C^3I capabilities as it does on the size and character of strategic arsenals. (C)

PD/NSC-53 directs that our C^3I programs and our guidance to telecommunications common carriers support the development and maintenance of such capabilities. In addition, PD/NSC-41 directs that we seek greater continuity of government should deterrence fail. Implementation of PD/NSC-53 and PD/NSC-41 must be pursued in parallel with that of this employment directive. (C)

The relationship of acquisition policy to employment policy. Our acquisition programs must be evaluated in terms of their support for the employment policy ordered by this directive. The required flexibility, survivability, endurance, and target destruction capability must be taken into account in developing programs for acquiring nuclear weapons systems, and their supporting C^3I systems, needed to support our countervailing strategy. (S)

Implementation. As new targeting capabilities are developed, and as our operational staffing support change to meet the foregoing directives, they must be reviewed and tested to validate their feasibility and soundness. For that purpose:

-- At least two exercises involving the National Command Authorities should be conducted each year to evaluate our capabilities and our employment doctrines.

-- Continued study and analysis of means to improve and refine our countervailing strategy of general conflict should be conducted by the Department of Defense.

-- The results of these exercises, studies and analysis will provide the bases for modification and any further development of employment and acquisition policy.

-- A report will be rendered to the President at least annually on our employment plans, including, but not limited to, on the size and capability of the reserve forces, the degree of flexibility available,

limiting factors in achieving flexibility, and the status of programs to provide improvements.

-- Any change or new pre-planned options will be submitted to the President for his review and approval, in accordance with current procedures. (TS)

NSDM-242 is superseded by this directive. (U)

Jimmy Carter

NUCLEAR WAR STRATEGY

(Concerning President Carter's 25 July 1980 Presidential Directive PD-59, "Nuclear Weapons Employment Policy")

HEARING

BEFORE THE

COMMITTEE ON FOREIGN RELATIONS
UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

PRESIDENTIAL DIRECTIVE 59

SEPTEMBER 16, 1980

(TOP SECRET HEARING HELD ON SEPTEMBER 16, 1980; SANITIZED AND PRINTED ON FEBRUARY 18, 1981)

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APPENDIX

ADMINISTRATION'S RESPONSES TO QUESTIONS SUBMITTED BEFORE THE HEARING

Question 1. What are the basic strategic targeting priorities in PD–59? How do these differ from previous targeting guidance, particularly that contained in NSDM 242?

Answer. PD–59 specifies the development of plans to attack a comprehensive Soviet/Warsaw Pact target system, with the flexibility to employ these plans, should deterrence fail, in a deliberate manner consistent with the needs of the situation and in a way which will deny an aggressor any gain, or would impose costs which clearly exceed his expected gains. This could entail initial retaliation on military and control targets while retaining the capability either to withhold for a relatively prolonged period, or to execute, broad retaliatory attacks on the political control system and on general industrial capacity. These individual target systems, which we feel the Soviet leaders value most, include leadership and control, military forces both nuclear and conventional and the industrial/economic base. Highlights of targeting aspects include an increased number of situation-oriented options, and more flexibility for selectively attacking all categories of targets.

PD–59 requires the option to attack a full range of industrial/economic targets be retained. PD–59 also places more emphasis on how to improve the effectiveness of targeting retaliation against Warsaw Pact leadership and control, nuclear forces, and conventional forces in a wartime situation. In contrast to some pronouncements by the press, the United States has never had a doctrine based simply and solely on reflexive, massive attacks on Soviet cities. Instead, we have always planned both more selectively (options limiting industrial/economic damage) and more comprehensively (a range of military targets in addition to the industrial/economic base). Previous Administrations, going back well into the 1960s, recognized the inadequacy of a strategic doctrine that would give us too narrow a range of options. The fundamental premises of our countervailing strategy are a natural evolution of the conceptual foundations built over the course of a generation. PD–59 is not a new strategic doctrine; it is not a radical departure from past U.S. strategic policy. Our countervailing strategy, as formally stated in PD–59, is in fact, a refinement, a codification of previous statements of our strategic policy. PD–59 takes the same essential strategic doctrine, and restates it more clearly, more cogently, in the light of current conditions and current capabilities.

Question 2. What are the fundamental political and military objectives for strategic targeting in PD–59? Is it envisaged that the United States could, under certain circumstances, conduct limited nuclear war for foreign policy, political or military objectives? Does the PD–59 envision the possibility of U.S. nuclear retaliation for any provocation short of a nuclear attack on the United States or its allies?

Answer. Deterrence remains, as it has been historically, our fundamental strategic objective. The overriding objective of our strategic forces is to deter nuclear war. But deterrence must restrain an adversary from carrying out any of a far wider range of threats than just that of massive attacks of U.S. cities. We seek to deter any adversary from any course of action that could lead to general nuclear war. Our strategic forces also must deter nuclear attacks on smaller sets of targets in the United States or on U.S. military forces overseas, and deter the nuclear coercion of, or attack on, our friends and allies. Our strategic forces, in conjunction with theater conventional and nuclear forces, must also contribute to deterrence of conventional aggression as well. I say "contribute" because we recognize that neither nuclear forces nor the cleverest theory for their employment can eliminate the need for us—and our allies—to provide a capable conventional deterrent.

In our analysis and planning, we are necessarily giving greater attention to how a nuclear war would actually be fought by both sides if deterrence fails. There is no contradiction between this focus on how a war would be fought and what its results would be, and our purpose of insuring continued peace through deterrence. Nor is there a contradiction between this focus and a judgment that escalation of a "limited" to an "all-out" nuclear war is likely. Indeed, this focus helps us achieve deterrence and peace, by insuring that our ability to retaliate is fully credible. We must have forces, contingency plans, and command and control capabilities that will convince the Soviet leadership that no war and no course of aggression by them that led to use of nuclear weapons—on any scale of attack and at any stage of conflict—could lead to victory, however they may define victory.

Operationally, our countervailing strategy requires that our plans and capabilities be structured to put more stress on being able to employ strategic nuclear forces selectively, as well as by all-out retaliation in response to massive attacks on the United States. It is our policy—and we have increasingly the means and the detailed plans to carry out this policy—to ensure that the Soviet leadership knows that if they chose some intermediate level of aggression, we could, by selective, large (but still less than maximum) nuclear attacks, exact an unacceptably high price in the things the Soviet leaders appear to value most—their military forces both nuclear and conventional, their political and military control apparatus, and the industrial capability to sustain a war. In our planning we have not ignored the problem of ending the war, nor would we ignore it in the event of a war. And, of course, we have, and we will keep, a survivable and enduring capability to attack the full range of targets, including the Soviet economic base, if that is the appropriate response to a Soviet strike.

The United States already retains the option of using weapons in a limited way in response to a conventional attack on us or our allies if necessary. However, PD–59 does *not* propose a first strike strategy. We are talking about what we could and (depending on the nature of a Soviet attack) would do in response to a Soviet attack. Nothing in the policy contemplates that nuclear war can be a deliberate instrument of achieving our national security goals because it cannot be. But we cannot afford the risk that the Soviet leadership might entertain the illusion that nuclear war could be an option—or its threat a means of coercion—for them.

Question 3. What alternative targeting strategies were examined in the studies which preceded PD–59? On what grounds were such alternatives rejected? Was the President presented with alternatives to the targeting policy set forth in PD–59?

Answer. Alternative targeting strategies were addressed. The alternative strategies examined were: (a) strengthen existing policy; (b) focus more heavily on denying Soviets a favorable war outcome; (c) add higher confidence capability against some target systems; and (d) rely more heavily on assured destruction.

Under alternative (a) the forces and related C^3I to accomplish this strategy would be given added endurance.

Alternative (b) placed more emphasis on targeting of Soviet (and non Soviet Warsaw Pact) nuclear and conventional forces to assure that they could not expect to achieve a favorable outcome or a victory, however victory might be defined, while retaining an assured destruction capability.

Alternative (c) would require greater capabilities against certain Soviet forces than in alternative (b).

The last alternative, (d), also would avoid the need to make any improvements to the flexibility and endurance of strategic forces and C^3I.

Each of the alternatives was considered in light of: (a) what flexibility in our nuclear posture (i.e., how broad a range of options) is desired; (b) how much endurance do our forces and C^3I require; (c) how much capability is considered necessary; (d) costs of achieving these capabilities.

These considerations were weighed against the ability of each of the alternatives to deter the Soviets, taking into account Soviet attitudes toward concepts of nuclear war and perceptions of our capabilities and will, as well as the perceptions of our friends and allies. In the final analysis, a policy was selected which was judged to be most realistic considering the current relationship between the U.S. and the U.S.S.R., and the world situation, and considering the continued aggressive pursuit by the Soviets of comprehensive improvement in all aspects of military force capabilities, both nuclear and conventional.

A belief in the continuing utility of war as a policy instrument and the need for military superiority fit well into Soviet discussions of victory in a global conflict. It should be noted that Soviet civilian leadership has made statements as to the destructiveness of nuclear war and the need for U.S.-U.S.S.R. arms control measures. At the same time, it is appropriate to take note of high level Soviet statements which tend to point to a somewhat different direction. For instance, the Chief of the Soviet Strategic Missile Forces has observed that:

> The imperialist ideologists are trying to lull the vigilance of the world's people by having recourse to propoganda devices to the effect that there will be no victors in a future nuclear war. These false affirmations contradict the objective laws of history . . . Victory in war, if the imperialists succeed in starting it, will be on the side of world socialism and all progressive mankind. (Marshal of the Soviet Union N. I. Krylov, "The Instructive Lessons of History", ***Sovetskaia Rossiia***, August 30, 1969, UNCLASSIFIED).

President (and Marshal of the Soviet Union) Brezhnev is also on record as saying that:

> Let it be known to all that in a clash with any aggressor the Soviet Union will win a victory worthy of our great people, of the homeland of the October Revolution. (L. I. Brezhnev, Speech on the 50th Anniversary of the October Revolution, ***Pravda***, November 4, 1967, UNCLASSIFIED).

In addition to such doctrinal presentations, the Soviet leaders make evident through their programs their concerns about the failure of deterrence as well as its maintenance, and their rejection of such concepts as minimum deterrence and assured destruction as all-purpose strategic theories. As Secretary Brown has indicated, what is most troublesome is the heavy emphasis in Soviet military doctrine on the acquisition of war-winning (whatever the duration of the conflict) capabilities, and the coincidence (in one sense or another of the word) between their programs and what have been alleged as the requirements of a deliberate war-winning strategy. This compilation of Soviet sources—which could be added to almost indefinitely—is sufficient to demonstrate that the Ogarkov quotation used in the speech quoted in the question was not an aberration. There are, to be sure, quotations to be found that indicate different views—partly because there are no doubt different views within the Soviet system, more often because they are addressed to different audiences. There is no question that the Soviet leadership understands that nuclear war would be immensely destructive and uncertain; it is to re-inforce that perception—and to add to it the conclusion, found only very infrequently if at all in public statements, that the U.S.S.R. could not fight and win such a war—that the countervailing strategy is directed.

O

FOR EXTERNAL PUBLICATION

Radio Moscow in Mandarin to China, Nov. 3, 1978.

"However, the fact is that China's digging deep tunnels can never protect the Chinese masses from nuclear bombing or even protect them from conventional heavy bombs."

* * * * * * * * * *

Radio Moscow World Service in English, Nov. 16, 1978

"The U.S. Administration is going to launch a 5-year program of civil defense. - - - The only real safety for the Americans is strengthening friendship with the Soviet Union, not bomb shelters."

FOR INTERNAL PUBLICATION

Moscow Voyennyye Znaniya in Russian No. 5, May 1978, p. 33.

"It is appropriate to say that we still meet people who have an incorrect idea about defense possibilities. The significant increase in the devastating force of nuclear weapons compared with conventional means of attack makes some people feel that death is inevitable for all who are in the strike area. However, there is not and can never be a weapon from which there is no defense. With knowledge and the skillful use of contemporary procedures, each person can not only preserve his own life but can also actively work at his enterprise or institution. The only person who suffers is the one who neglects his civil defense studies."

~~TOP SECRET~~

DEPARTMENT OF DEFENSE

A-38/

POLICY GUIDANCE FOR THE EMPLOYMENT OF NUCLEAR WEAPONS (NUWEP) (U)

OCTOBER 1980

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~~CONFIDENTIAL~~

THE SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

24 OCT 1980

MEMORANDUM FOR THE SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARIES OF DEFENSE
ASSISTANT SECRETARIES OF DEFENSE
ASSISTANTS TO THE SECRETARY OF DEFENSE
DIRECTOR, NET ASSESSMENT
DIRECTORS OF DEFENSE AGENCIES
COMMANDERS-IN-CHIEF OF THE UNIFIED AND SPECIFIED COMMANDS

SUBJECT: Policy Guidance for the Employment of Nuclear Weapons (NUWEP)

To enhance deterrence and thereby reduce the dangers of nuclear war -- which is at once a military, a political, and a moral objective -- we must continue to pursue an integrated policy of force modernization, equitable and verifiable agreements on arms limitations, and more credible doctrine and plans for the employment of nuclear weapons. To insure achievement of the latter, the attached Policy Guidance for the Employment of Nuclear Weapons (NUWEP) sets forth in accordance with national guidance (PD-59) policy for the employment of nuclear weapons.

NUWEP has important elements of continuity with past guidance, but it is intended to yield improvements in employment flexibility, provide the basis for strengthening endurance of forces and supporting C^3I, and produce better interaction between policymakers and military planners. We should seek through plans we develop, the forces and C^3I systems we procure, the exercises that we conduct, and the operational practices we employ to convince our adversaries that they could not and would not "win" a nuclear war in any meaningful sense, however they may define winning. To this end each of you should fully understand and carefully take into account the attached policy guidance in future actions.

Harold Brown

~~CONFIDENTIAL~~

IV. STRATEGY FOR EMPLOYMENT

A. Flexibility

(U) The U.S. must have the capability to respond appropriately and effectively to any level of Soviet aggression, over the continuum of nuclear weapon employment options, ranging from use of a small number of strategic and/or theater nuclear capable weapon systems in a contingency operation, to a war employing all elements of our nuclear forces in attacks against a broad spectrum of enemy targets. The ability to respond with selectivity to less than an all-out Soviet attack in keeping with the needs of the situation is required in order to provide the National Command Authorities (NCA) with suitable alternatives, strengthen deterrence, and enhance the prospects of limiting escalation of the conflict. In addition to pre-planned options we need an ability to design employment plans on short notice in response to the latest and changing circumstances. To advance the goal of flexibility, planning will provide an objective-oriented series of building block options for the employment of nuclear weapons in ways that will enable us to employ them consonant with our objectives and the course of the conflict.

~~(C)~~ As it evolves, the building block approach should provide plans which satisfy a hierarchy of targeting objectives and which will provide the NCA an improved capability to employ nuclear weapons effectively in as measured and controlled a manner as feasible in case of a limited conflict. It should provide complementary elements which can be combined in an integrated and discrete manner to provide larger and more comprehensive plans for achieving politico-military objectives in specific situations. The building block approach places emphasis on the individual elements, their objective utility, and our ability to employ them separately or in total. However, this does not imply that the total plan be finely divisible--practical realities cannot be ignored. The desire for enhanced flexibility in employment must be balanced by practical consideration of the increased complexity incurred in planning and operations, the need to avoid compromising the effectiveness and workability of the larger options, and the need to maintain a responsive decisionmaking and force execution process.

B. Endurance

~~(S)~~ Endurance of forces and supporting C^3I can strengthen the US defense posture by: (1) ensuring that the U.S. is not placed in a "use or lose" situation that might result in an unwarranted escalation of the conflict; (2) providing a hedge that allows us to adapt the employment of our forces across the spectrum of nuclear war; and (3) (b)(1) [redacted]

RECOVERY FROM NUCLEAR ATTACK

by

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DCPA01-78-C-0270
Work Unit 3539B
Dr. David W. Bensen (COTR)

December 1979

INTRODUCTION

On December 5, 1945, just 4 months after the news flash that an atomic bomb had been developed by the United States and had been dropped on Japan, Dr. Hans Bethe, Nobel prizewinner and one of the designers of the bomb, was called before the Special Committee on Atomic Energy of the U.S. Senate. The Committee was concerned that an atomic explosion might "ignite" the earth's atmosphere or start some sort of chain reaction in the air or in the ocean.

Dr. Bethe succeeded in reassuring the Committee that these and other "end-of-the-world" type effects are not to be expected. In general, such extreme fears no longer are taken seriously. However, other almost equally catastrophic visions have arisen to take their place. They include:

— the triggering of a new ice age, to be caused by the vast quantities of debris that would be thrown into the stratosphere and would serve to deflect the sun's rays away from earth. (Although we cannot rule out the possibility of some changes in climate if a very large scale nuclear exchange should occur, most of the particles would descend airly quickly and the changes in climate, even if noticeable, would be transitory.)

— upsetting the delicate balance of nature, leading to disastrous changes in the ecological systems. For example, it has been suggested that since birds are more sensitive than insects to gamma radiation, fallout could kill off the birds - the predators - leaving the insects - the prey - to multiply without control. (Study has shown that when other relevant factors are considered, this is not likely to occur. The insects would be subjected to much more beta radiation than the birds, and control mechanisms other than simple predator/prey relationships affect population control.)

— creation of vast radioactive wastelands that would be uninhabitable for generations. Some areas, especially near ground - zero of surface - burst weapons, would continue to be highly radioactive for many years. (Much of the country, however, would be scarcely affected at all and much of it initially interdicted because of fallout could be reclaimed by decontamination, or, within weeks or months, could be used after the natural radioactive decay had reduced the radiation levels to acceptable values.)

— great increases of leukemia and other malignancies among the survivors - due to exposures to fallout radiation. In the 50's and early 60's many people believed that survivors of a nuclear attack inevitably would die of bone cancer from Strontium-90, (Research has shown that Strontium-90 is not the hazard it was first thought to be. The basic reason is that most of the bomb-produced Strontium-90 is not "biologically available;" that is, it does not get into the food chain. Also, methods for decontaminating food have been developed if the need should ever arise. Some increase in the rate of malignancy among survivors of a nuclear attack would be expected, but in no sense would the increase threaten the survival of the society.)

— vast increases in congenital defects due to gene mutations caused by radiation, lasting for many generations. (Some radiation-induced genetic mutations would occur among the survivors of a nuclear war, but, as in the case of the malignancies, their impact would not be important in terms of the survival of the society.)

— depletion of the ozone layer in the stratosphere. This could decrease protection from ultraviolet radiation and cause proliferation of skin cancers, kill wild and domestic animals, and make it difficult, if not impossible, to grow many of the crops that provide our food and fiber. (This hypothesis is the latest and its validity is yet to be established one way or the other. If research confirms that ozone depletion resulting from the detonation of nuclear bombs is a serious potential hazard, research would be needed to evaluate the degree of the hazard and what could be done to reduce its effects.)

— breakdown of our highly sophisticated and complex social and economic systems due not only to loss of key facilities and personnel, but also because of functional disruption and behavioral breakdowns. (This hypothesis is less specific than those relating to the physical effects of nuclear weapons, and is much more difficult to formulate or investigate. It remains at this time one of the major "unknowns.")

An underlying basis for these negative hypotheses may be psychological. If everyone "knew" that nuclear war would mean the end of the human species, somehow the world would appear more secure since no sane person would initiate a series of events that would lead to everyone s death, including his own. In such a way does the idea of "assured destruction" contain elements of reassurance to some people.

The potential threats to recovery from nuclear war have received a significant amount of study. The Defense Civil Preparedness Agency (and its predecessors) in the decade from 1963 to 1973 allocated some $17 million to research in the general area of postattack recovery. The Federal Preparedness Agency (and its predecessors) have conducted both contract and in-house research at a cost of another several million dollars, with much of this FPA work focused almost exclusively on the problem of economic recovery.

Other agencies have also been involved. From the early days following World War II the former Atomic Energy Commission and its successors, now the Department of Energy, have sponsored elaborate research programs aimed at investigating the various possible deleterious consequences of exposure to ionizing radiation and developing means of protecting against them. This radiological research program has included a cooperative effort with the Japanese to study the longer-term effects of radiation exposure on the survivors of Hiroshima and Nagasaki and their offspring. This program continues today, and will for many years to come.

To date, approximately $1.5 billion has been allocated by the AEC and its successors for research associated with ionizing radiation and its effects. From these 30 years of scientific studies, much is known about the hazards of radiation — more than is known about many of the other hazards that man faces, probably including the common cold.